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The Pacific Power Plant

The Journal of Electricity

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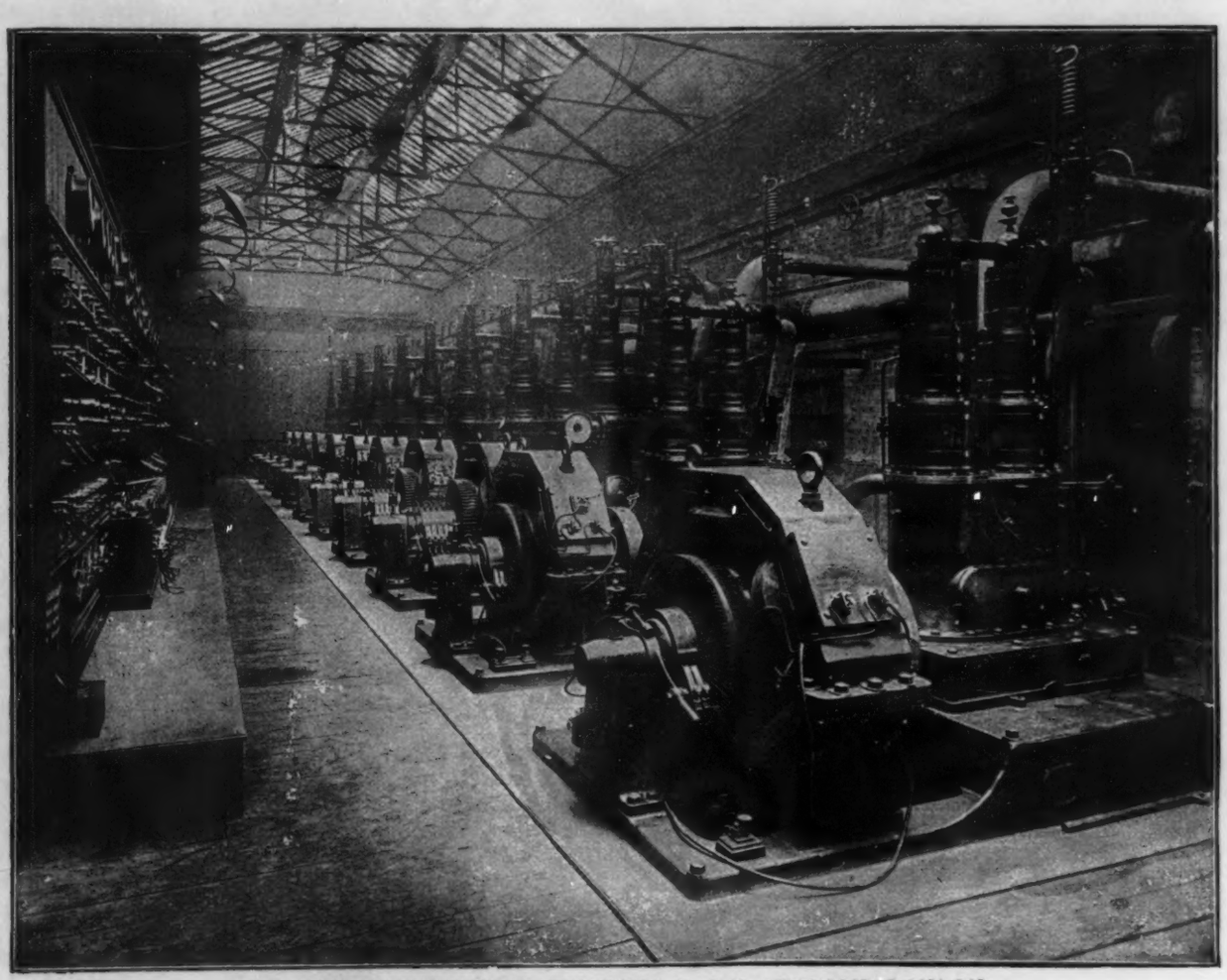
The Journal of Electricity

Vol. IV. JUNE, 1897. No. 3

The Pacific Power Plant.

The Pacific Power Company owns nearly the entire block bounded by First, Mission, Stevenson and Ecker streets, in San Francisco, as well as most of the buildings thereon, and as these structures are well in the midst of the manufacturing district, it was desirable that the premises should be rented with power. It was thus that the Pacific Power Company found a reason for its organization, and from a modest neuclus it has grown quietly and but little known until now it is furnishing power to many blocks in its vicinity, and is, moreover, one of the most substantial corporations in San Francisco.



ST. PANCRAS VESTRY, REGENTS PARK STATION, LONDON.

Electricity was indeed "in its infancy" when the Pacific Power Company first undertook its use as an agent for distributing power over districts too remote to be reached economically by the lines of countershafting that it had extended underground throughout its own block and those immediately adjoining. The first apparatus installed was designed and made by Dr. N. S. Keith, who was then of San Francisco, who was founder of the American Institute of Electrical Engineers and who has recently achieved considerable new fame in England by reason of new processes he has developed for the reduction of refractory ores. This pioneer installation consisted of four 40 horse power horizontal field, bipolar dynamos, with armatures parallelling the axes of the fields. These machines were of a simple shunt wound, constant current type, having an output of approximately 15 amperes. The field was regulated by cutting 100 volt incandescent lamps in or out of

the field circuit and the constant attention of a switchboard attendant was required to keep the amperage at, or rather near normal, for, with the plain series motors used, the throwing off of five or ten horse power by a consumer, worked the ammeter needle into a terrified frenzy. Housetop distribution was used, with "undertakers'" wire, and while in the light of present knowledge the plant was woefully primitive and its efficiencies had perhaps better not be discussed, nevertheless it gave satisfactory service for nearly a decade. In 1894 the venerable old plant was relegated to the scrap pile and an underground system was installed under the specifications and supervision of Messrs. Low & Sprout, electrical engineers, whose business is now carried on by Mr. Sidney Sprout.

The new system of the Pacific Power Company consisted of a 113 kilowatt, 500 volt, Westinghouse multipolar generator of the then latest type, together with a distributing system embracing about twenty business blocks and containing over two miles of underground conductors. All conduits were of wrought iron pipe, all manholes were of brick laid with cement, with cast iron covers and all conductors were lead-en cased. The great success of the plant resulted in such rapid growth that within a year material extensions became necessary, among which was the installation of a second Westinghouse generator, which is a duplicate of the one first erected. Still the business increased at such pace that now the thoroughly modern plant about to be described has been installed and the results it has achieved have been so eminently satisfactory, and the efficiencies attained have so far eclipsed any heretofore reached that it has been determined that all future extensions shall be on the lines of this last installation.

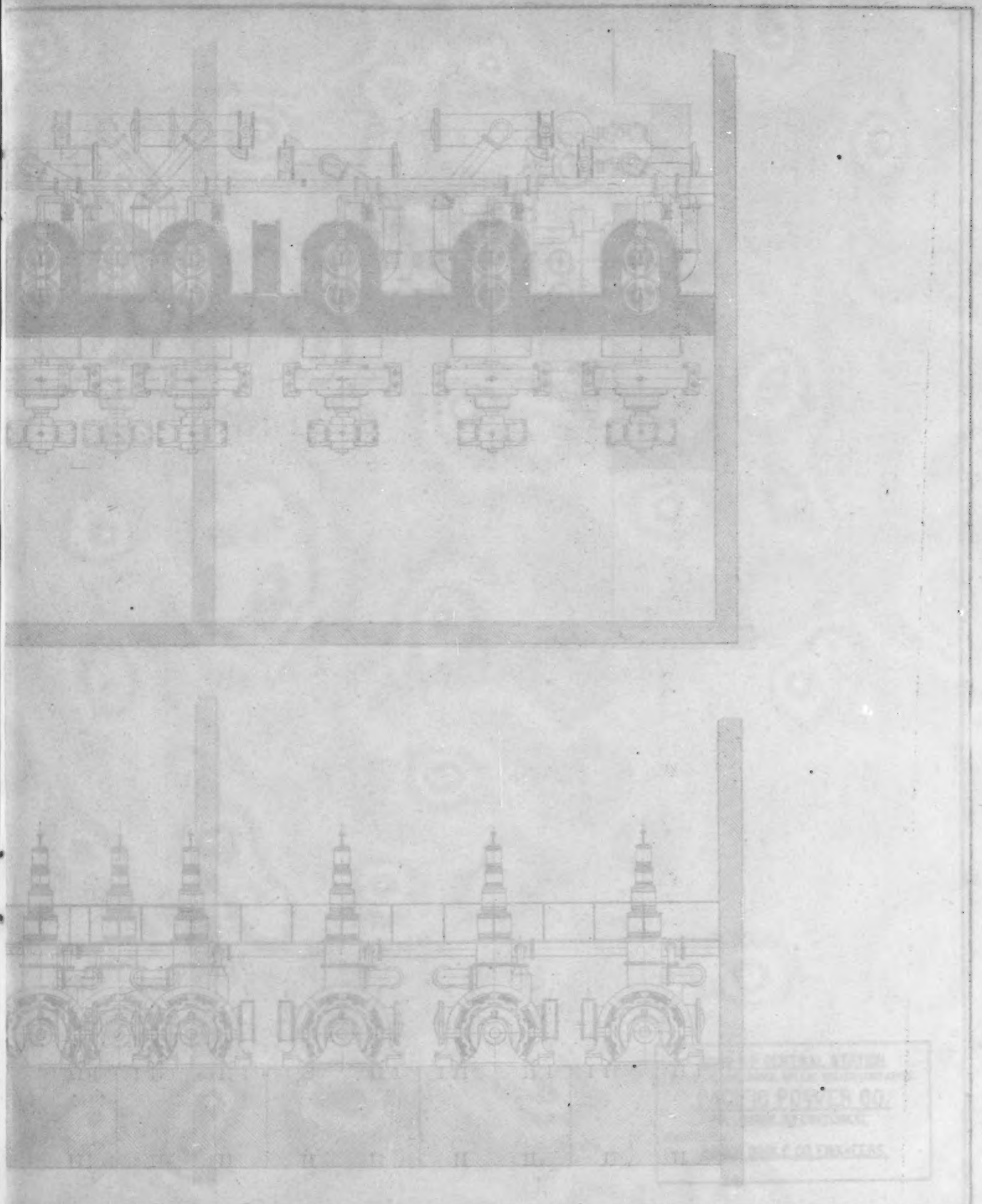
Before proceeding to a description of the plant, it is well to point out that the Pacific Power Company, through the able superintendence of Mr. Ira Bishop, has won the reputation of being able to get more power out of a ton of coal than any other steam power producer on the Pacific coast. Indeed, the attaining of this distinction seems to have been its ambition, with the result that there is probably not to be found west of the Rockies a concern which has given longer years of more patient study and experimenting, or which has made such exhaustive and elaborate tests, or has followed to the most minute detail every item of the cost of power, or has for years required such exacting reports from employees, than has the Pacific Power Company. No item of expense has ever been too small for searching scrutiny; no cost of experimenting or test has ever been a deterrent from ascertaining the facts regarding any feature forming a factor of the cost of steam power. A number of years ago it built at great expense a pipe line through which it pumps condensing water from the bay; for years it has weighed every pound of water going through the boilers and every ounce of coal burned, and it was the first concern on the Pacific coast to buy coal by the amount of water evaporated and to saddle upon the coal dealer the "personal equation" of the fireman. It will not be doubted, therefore, that the Pacific Power Company has reduced the science of central station economics to a fine art. Moreover, until a year since, the Pacific Power Company carried on an extensive engineering and manufacturing business under the name of the San Francisco Tool Company, which was also under Mr. Bishop's management, and which built steam engines, mining machinery, centrifugal pumps, and, in brief, all classes of mechanical engineering work, even to cable railway systems.

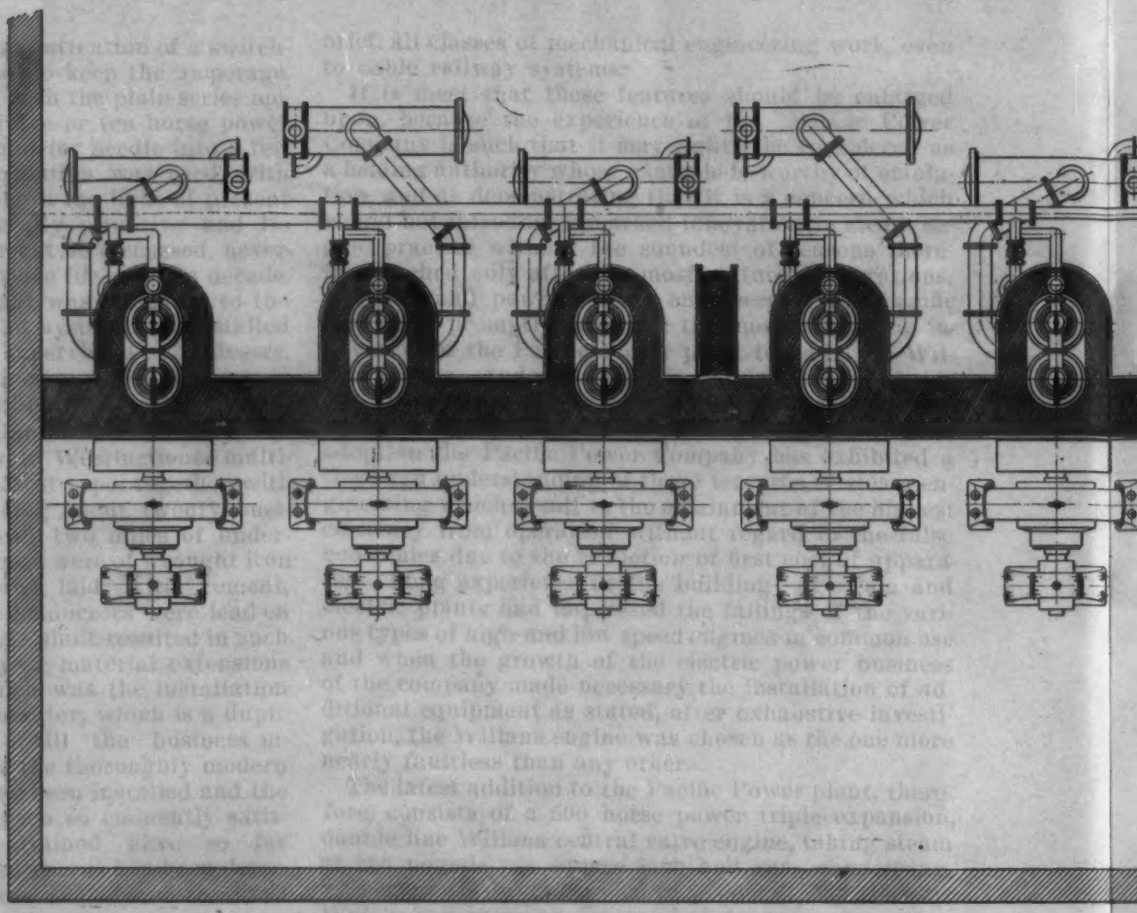
It is meet that these features should be enlarged upon, because the experience of the Pacific Power Company is such that it may rightly be considered as a leading authority whose example is worthy of emulation, and as demonstrating that it is a concern which would not introduce a marked innovation in steam engine practice without the soundest of reasons therefor, reached only after the most mature deliberations.

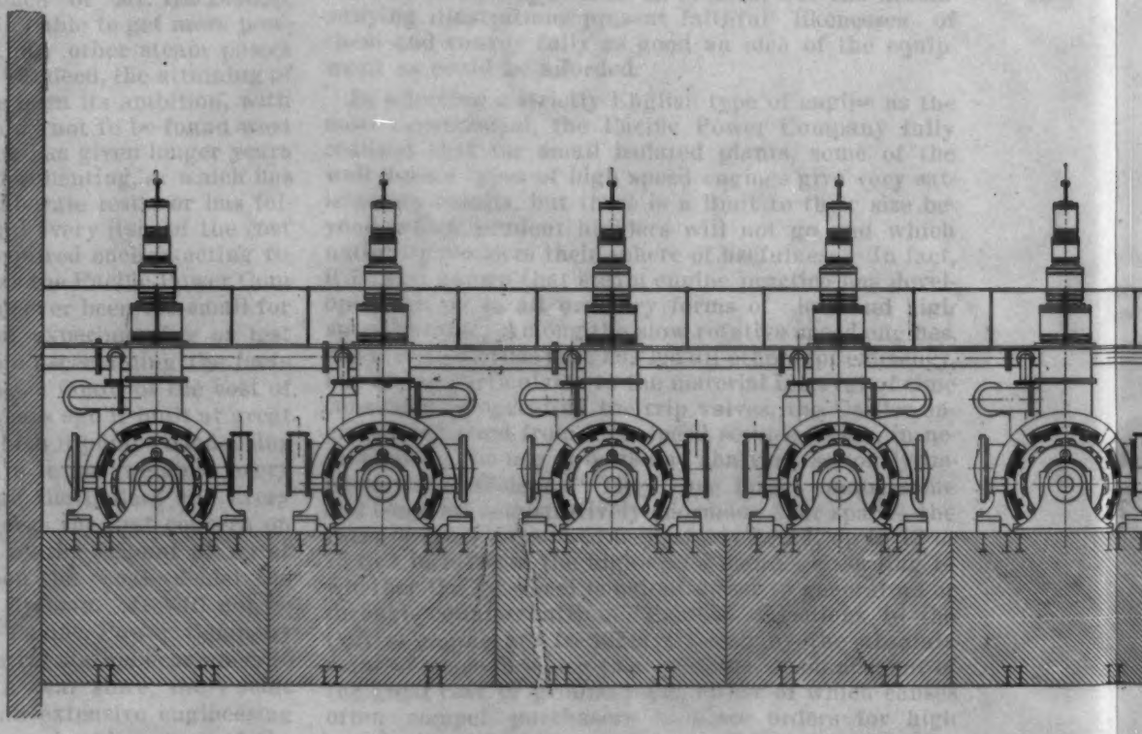
Steam and power station engineers of the Pacific coast will promptly recognize the most interesting innovation of the Pacific Power plant to lie in the Willans engine. Indeed, as this is the first engine of this class that has been erected west of the Rockies, its installation merits more than passing notice and in its adoption the Pacific Power Company has exhibited a thorough understanding of those features of steam engineering which result in the attainment of the highest efficiency from operation without regard to the false economies due to the reduction of first cost of apparatus. Long experience in the building of steam and electric plants had impressed the failings of the various types of high and low speed engines in common use and when the growth of the electric power business of the company made necessary the installation of additional equipment as stated, after exhaustive investigation, the Willans engine was chosen as the one more nearly faultless than any other.

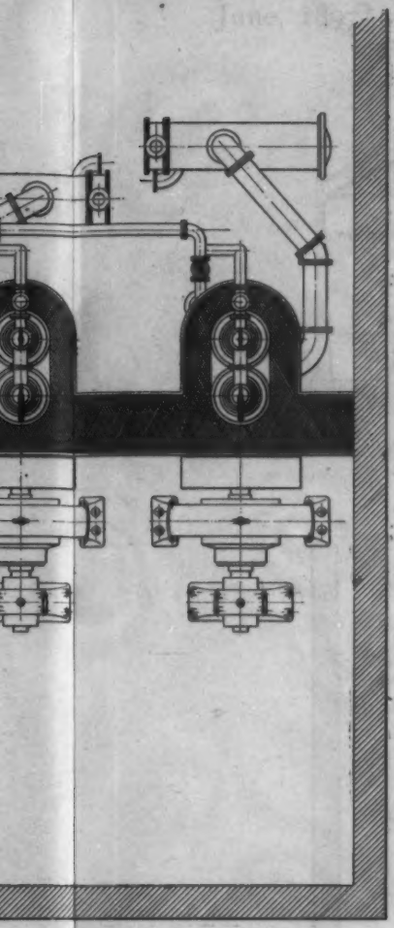
The latest addition to the Pacific Power plant, therefore, consists of a 500 horse power triple expansion, double line Willans central valve engine, taking steam at 200 pounds per square inch and run condensing. This engine is direct coupled to a 500 volt, 300 kilowatt Walker generator, the engine and dynamo set running at 300 revolutions per minute. Owing to the locations of the engine and generator it has been found impossible to photograph them as erected, but the accompanying illustrations present faithful likenesses of them and convey fully as good an idea of the equipment as could be afforded.

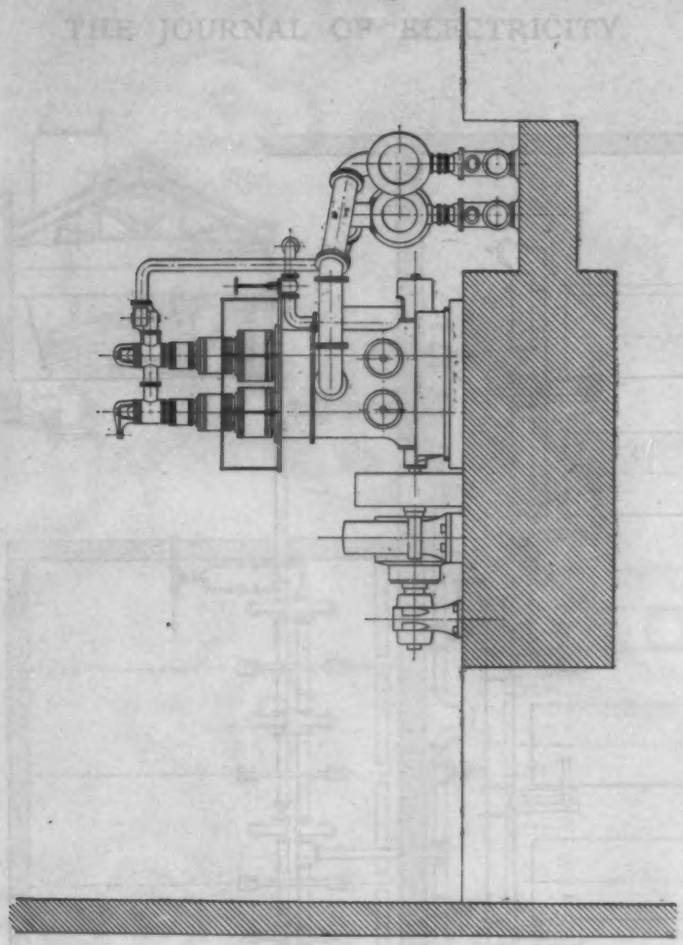
In selecting a strictly English type of engine as the most eceonomical, the Pacific Power Company fully realized that for small isolated plants, some of the well known types of high speed engines give very satisfactory results, but there is a limit to their size beyond which prudent builders will not go and which naturally restricts their sphere of usefulness. In fact, it is well known that steam engine practice has developed defects in all ordinary forms of low and high speed outfits. Among the slow rotative speed engines, the famous Corliss type has led all others for efficiency, but owing particularly to the material interval of time consumed in operating the trip valves, the Corliss engines are barred from high speed service which, in necessitating the use of belts and shafting, seriously impairs their efficiency. They are large, cumbersome and consume comparatively enormous floor space—the ratio of space consumed being from 8 to 1, up to 12 or 15 to 1 in favor of the high speed engine, according to whether the fly wheel is belted direct to generators or through countershafting. Further objections to the Corliss engine are frequently found by the absolute want of space in which to erect them, or on account of the great cost of ground room, either of which causes often compel purchasers to place orders for high speed engines, which are in some instances otherwise greatly inferior to Corliss engines both in durability and in economy in the use of fuel. In Corliss engines the number of working parts require considerable care

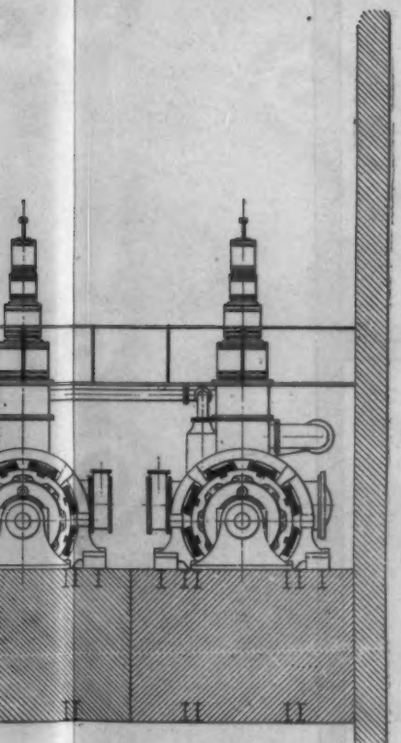












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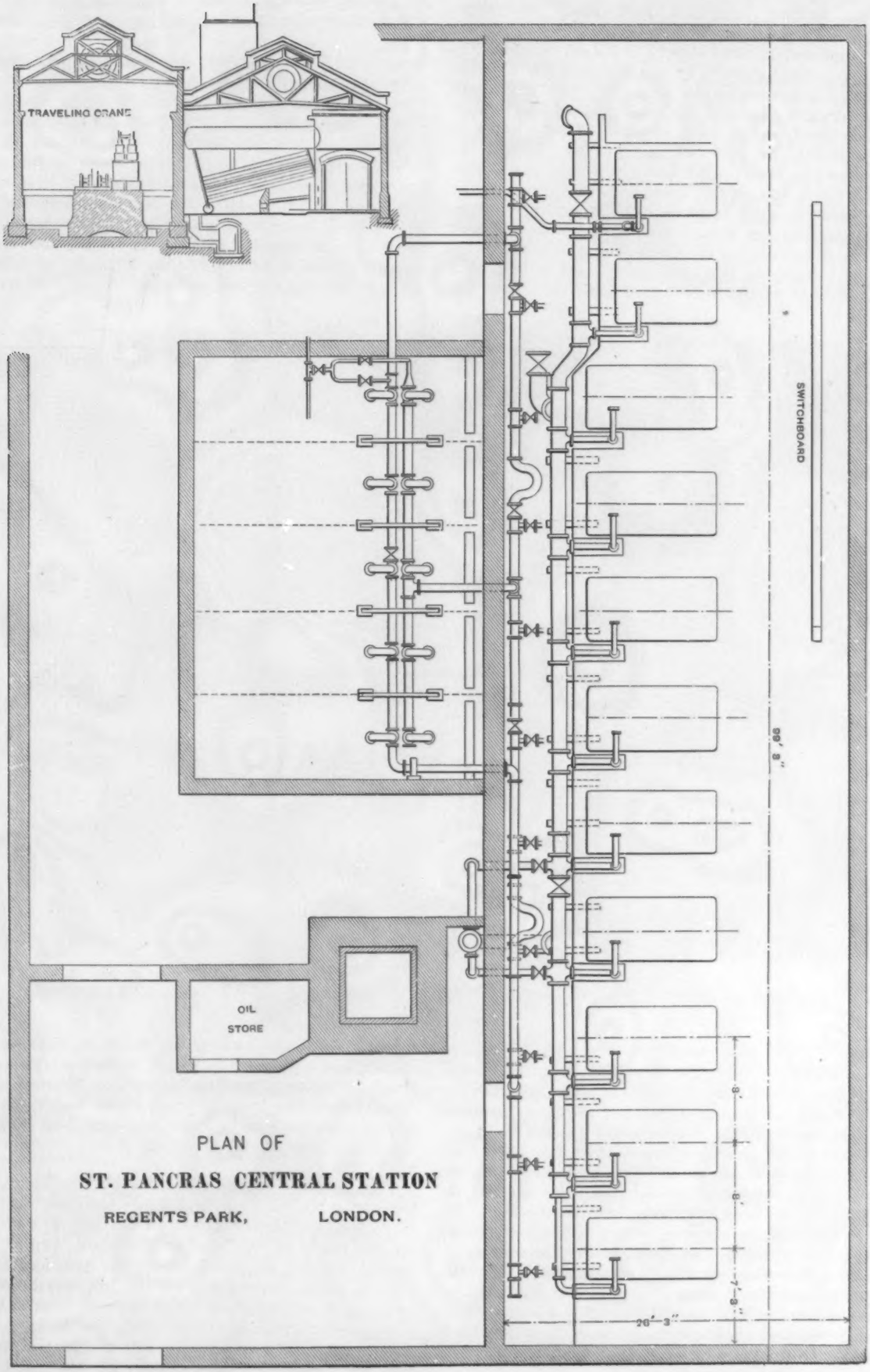


PLAN OF

ST. PANCRAS CENTRAL STATION

REGENTS PARK, LONDON.

and they are expensive to maintain in the matters of lubrication, belting, clutches and shaft bearings. Moreover, they bend ungraciously to the will of the governor and respond but slowly to its commands.

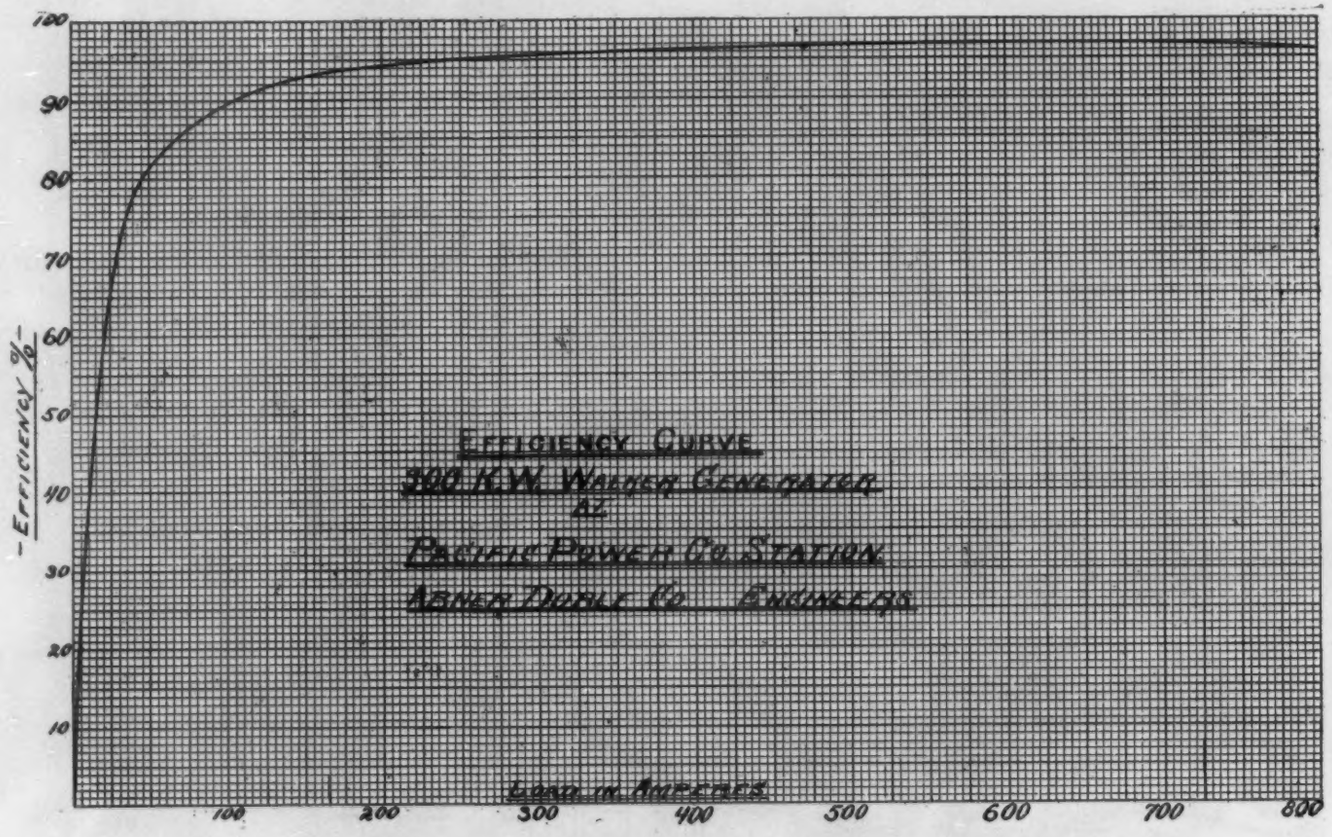
The phenomenal growth in the demand for electric lights for all purposes in the past ten years has modified and radically changed the conditions under which plants were installed, to such an extent that what was then considered the acme of engineering, is now severely criticized, and considered a rudimentary example of the past; and as the demands for engines to be used for electric work increase, the objections to the use of Corliss engines were found to increase in direct ratio. The objections to the Corliss engine all increase its cost and decrease its efficiency, and it is a well known fact that ofttimes belt transmission alone absorbs from 10 to 15 per cent of the power of the engine.

These drawbacks led to the development of the high speed engine of ordinary forms, wherein the different types partially or wholly eliminate the most serious disadvantages of Corliss engines, but gradually faults in the newer forms have developed until now their perfection is no longer conceded. The high speed of the reciprocating parts results in wearing the brasses so that knocking or back-lash can only be avoided by their frequent taking-up, and the number of steam carrying parts which are exposed to the air results in material condensation with loss of efficiency. The oil cups require constant attention and the difficulty of drainage in vertical high speed engines is a serious one.

In brief, the best high speed engine is the one which most nearly conforms with the ideal requirements set forth in the following points:

1st. Maximum economy of fuel.
2nd. " " attendance.
3rd. " " oil.
4th. " " space.
5th. " " time overhauling and making repairs.
6th. Greatest durability.
7th. Self-Lubrication.
8th. Noiseless running.

The broad minded engineer in quest of the greatest refinements that have been accomplished in his art will not be blinded by sentiments of national prejudice, but instead will search the world over for the best. It was thus that an extended and painstaking investigation, by the Pacific Power Company, both at home and abroad, developed the fact that while the American electricians were leading the world in developing electricity and applying it to all industrial purposes, an English engineer, finding himself confronted with conditions differing greatly from those under which American engineers have been working, had quietly met the difficulties above enumerated and conquered them all.



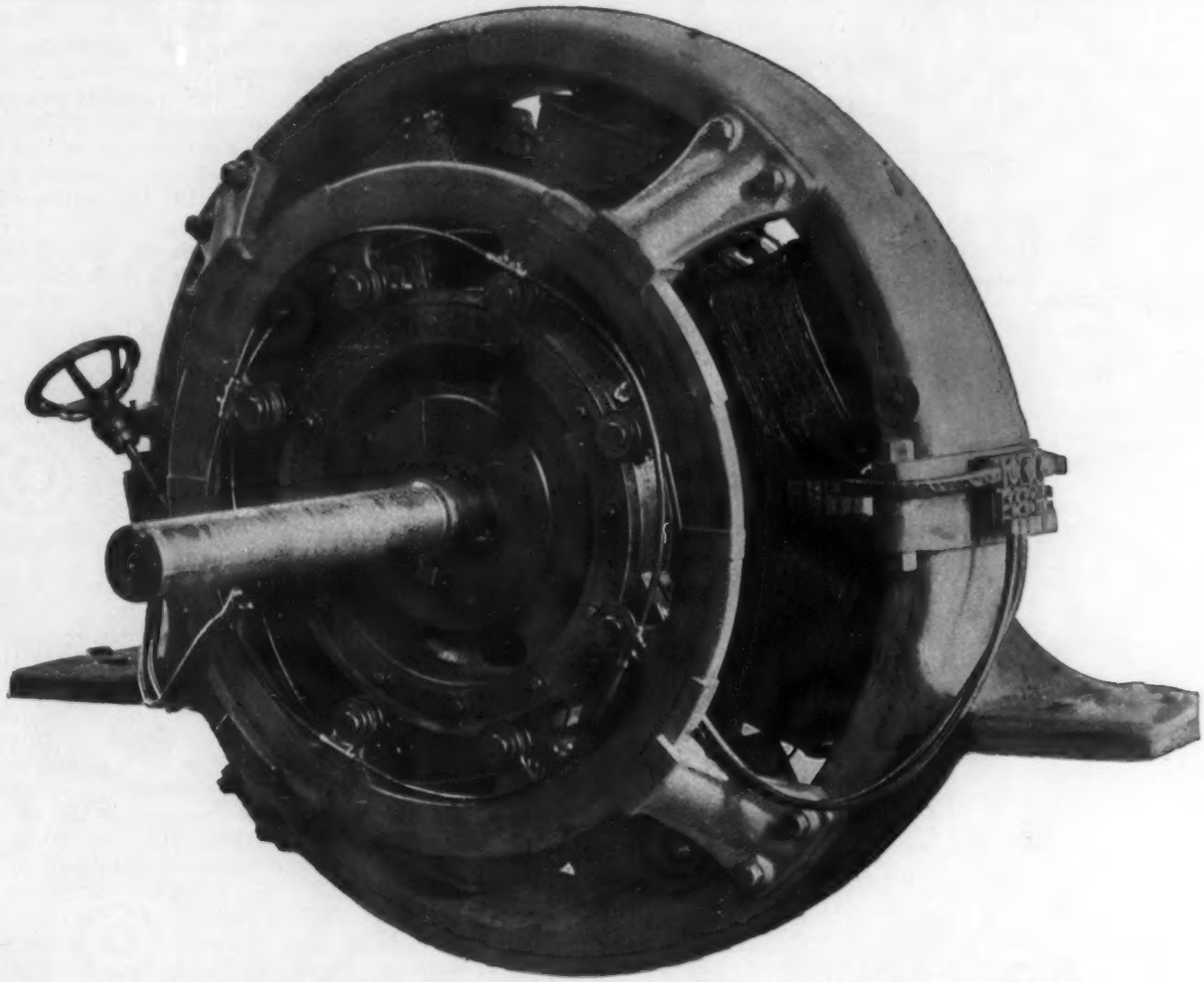
EFFICIENCY CURVE OF THE PACIFIC POWER COMPANY'S WALKER GENERATOR.

The Willans engine installed by the Pacific Power Company is an American-made engine, built by the M. C. Bullock Manufacturing Company of Chicago, upon the plans of Willans & Robinson, Ltd., Thames-Ditton, Surrey, England, where the firm has a very extensive plant, embodying all the improvements known to modern engineering. For several years they have been manufacturing Willans engines in large quantities, making all parts to jigs and templates, and therefore perfectly interchangeable, their standard of excel-

lence being higher than anything that has ever before been attempted in steam engineering, their limits of inspection ranking with the best American manufacturers of fine tools.

It is very interesting to relate that the great success of the Willans engine must be ascribed to the admirable system of manufacture and testing carried out at their works. All the parts of their engines are readily interchangeable and the workmanship is perfect. A writer in The Engineer some time ago paid a visit to Messrs. Willans and Robinson's works. In the course of his admirable remarks on the good work done, he says: "Gages are specially noteworthy, as it is by their universal adoption that absolute uniformity is secured in the diameter of the cylinders, trunks, etc. As an example of this we were shown a large collection of cylinders, from which we were asked to make a selection at random. We did so, whereupon the cylinder was laid on a small surface plate as in Fig. 7. The plate was slightly coated with oil, so as to insure an airtight junction between the two. Now for the test. The gage for this size of cylinder was dropped into the cylinder. Did it fall to the bottom? No; it remained supported at the top on a perfect air cushion, and so exact was its fit, that when struck with a hide mallet, stamped upon, it responded by merely vibrating up and down, alternately compressing and being raised again by the cushion on which it sits, and gradually settling down to its normal state of suspension. It is this easy movement that makes the experiment so pretty, showing how exactly the necessary diameter to insure it, and at the same time entirely imprison the air beneath, has been hit."

The same writer gives another instance which shows the perfect workmanship which is secured by Messrs. Willans & Robinson. "The 60 indicated horse power compound engine—shop engine—the upper parts of which were exhibited at the Institute of Civil Engineers on April 18, 1893, is a proof to show of what these engines are capable. It should be remembered that the parts exhibited had been running since July, 1889, and had undergone unusually severe running, probably equal to five years of ordinary running. No part had previously replaced except one piston ring, and the signs of wear were very slight. An important fact in connection with the replacement of parts was the astonishing rapidity with which it was done, as all the parts except the base were removed during the dinner hour on April 18, and replaced by similar new parts taken from the stores, allowing the engine to be started at two o'clock."



THE WALKER GENERATOR INSTALLED BY THE PACIFIC POWER COMPANY.

As the Willans engine is a decided novelty in the Far West, it is fitting that in view of its extraordinary economy, it should be fully described:

The engine is single acting, and on the "constant thrust" principle—that is to say, the connecting rods

are always in compression. All the brasses are held close together, both upon the up stroke and upon the down stroke. The latter is the working or effective stroke. During the first portion of it the steam pressure on the pistons, of course, presses all parts against the cranks and the crankshaft against the lower main bearing brasses; in the later portion of the down stroke

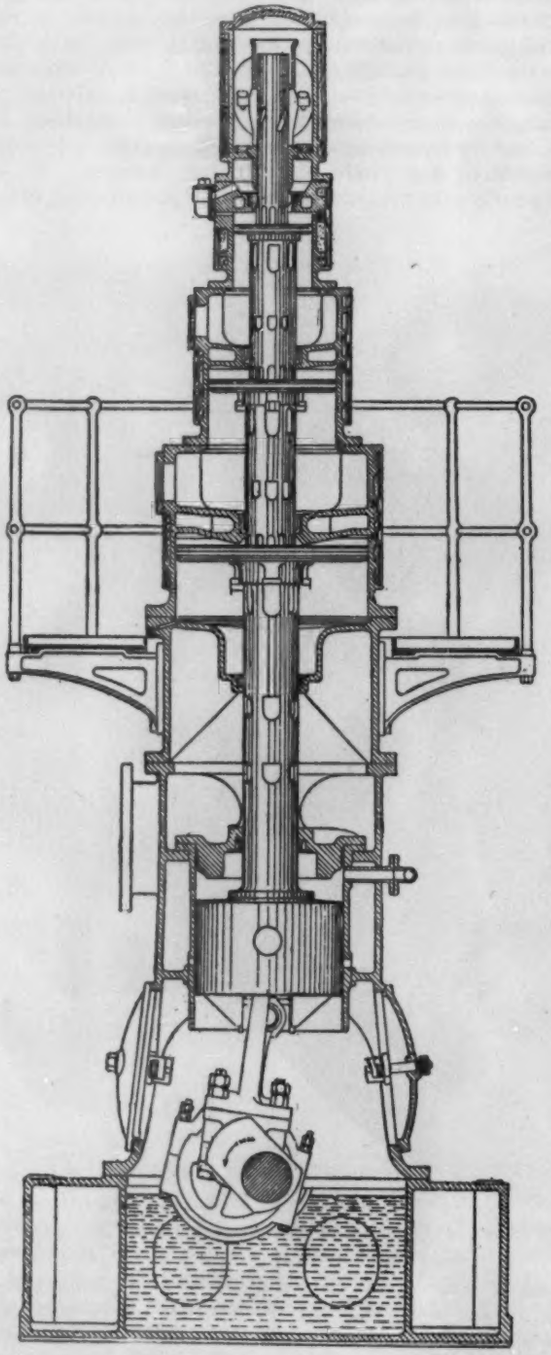


FIGURE 1.—OUTLINE SECTION OF A TRIPLE EXPANSION CENTRAL VALVE ENGINE.

the inertia of the parts, as they are brought to rest by the changing angle of the crank, also helps to keep them in compression. On the up stroke, when no work is being done, and when the steam is being merely exhausted from the several cylinders, the inertia of the parts, as they undergo acceleration by the crank, also keeps them in compression for the earlier portion of the stroke; in the latter portion they are cushioned by the arrangement to be described. The result is that in no part of the stroke, up or down, do the parts tend to separate; consequently there is a total absence of "back lash" or "lost motion," and "knock" cannot arise as it would if the engine were double acting, particularly in view of the high speed adopted.

The piston speed, however, is lower than in most engines, and the wear in cylinders and piston rings is consequently small, while that in the brasses owing to the total absence of hammering and of back lash, is very small indeed. The valves working inside the piston rod in the manner shown on this page, give an excellent distribution of steam and unequaled drainage for water. The high speed is in itself conducive to economy, and the Willans engine, as proved by many tests of undoubted authority, stands absolutely at the head of all types of steam-engine as an economical motor—the largest and best types of Corliss engine not excepted. With a small engine indicating only 20 h. p. (at 400 revolutions per minute) a consumption of less than 13 lbs. of steam per i. h. p. per hour, condensing, has been recorded, and a little over 18 lbs. non-condensing.

The outline cut on this page shows a triple expansion condensing engine in section (through one line of cylinders). The steam is distributed throughout by the hollow piston rod. It enters from the steam chest by the oblique cut-off ports shown near the top of the piston rod. By the movement of the line of piston piston valves, which work inside the piston rod or trunk, driven by an eccentric, the steam passes into the high pressure cylinder, at the beginning of the stroke, by the ports shown above the high pressure piston. It is important to remember that this ring of ports is the only inlet to and outlet from the cylinder, and it moves up and down with the piston.

The action of the valve inside is shown in detail in Fig 2, which represents it in the exhaust position. The valve gives just the same steam distribution as an ordinary slide valve, with a slow cut-aff at about three-quarter stroke. The actual cut-off is, however, effected by the oblique ports in the steam chest, which, at a point in the stroke, either prearranged or controlled by the governor, pass behind rings, or a sleeve, so disposed as to prevent the further supply of steam for that revolution. As the cut-off motion is the same as that of the pistons themselves, the cut-off is very prompt, and shows a sharp corner in the diagram.

It must be impressed that the hollow piston rod passes completely through the line of pistons, and through the ends of the cylinders. The reason the eccentric is on the crank-pin, and not on the shaft as usual, is that the valve-face (i. e., the inside surface of the hollow piston rod) moves with the pistons. Consequently the valve-motion required is a motion relative to the pistons, and this is obtained by mounting the eccentric on the crank-pin, which like the piston-rod, moves up and down with the pistons. Though its lead is set out differently from that of an ordinary eccentric, its effect upon the movement of the valves is exactly the same.

It will be noticed that the upper crank-pin brasses of the connecting-rods are wider than the lower ones. This is because the upper brasses alone are intended to be in actual contact with the crank-pins; the lower ones are only a stand-by in case of accident. All the moving parts of the engine designed to be strictly in

constant thrust and the connecting rods are always in compression, never in tension. From the fact that the upper or working brasses never leave the crank-pins, and so are never exposed to hammering action, however slight, they exhibit great durability when properly lubricated; at the same time it is evident that no wear which can take place in them however great, can lead to knocking, as the connecting-rods will follow up the wear automatically. But as the lower brasses, to be useful as a stand-by, should not be too far from the crank-pin, the wear should be taken up when it becomes excessive, say as soon as it reaches 1-32 inch, care being used that the lower brasses are not brought actually into contact with the crank-pin, and that sufficient slack is left to insure an audible knock if the engine is allowed to race, so as to attract attention.

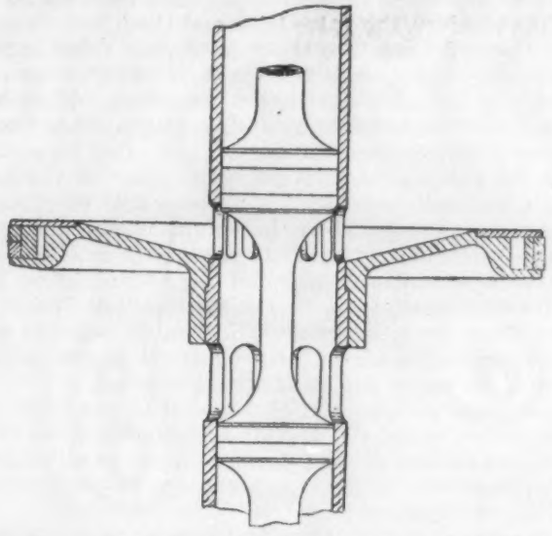


FIGURE 2.—A SECTION OF THE PISTON OF A WILLANS CENTRAL VALVE ENGINE.

In the sectional view appearing in the advertising pages (viii) appears a two-line Willans central valve compound engine showing the transfer chambers and the spiral cut off sleeve. A further reason for the moderate wear of the brasses and eccentric straps is that they dip bodily into the lubricant in the crank chamber at every revolution. In doing so they splash it over the main bearings and to the upper ends of the connecting-rods, and eccentric rods, and into the guide cylinders as well as into that part of the hollow piston-rod where the guide works. The lubrication of the working parts (other than steam pistons and valves) is thus completely automatic, and gives no trouble whatever.

The principle of working with all brasses "in constant thrust" is of the utmost importance and value, and is the primary cause, not only of the silent running of the Willans Engine, but of the almost complete absence of wear in the brasses. It is the condition which alone makes continuous high speed possible.

After the steam has worked expansively in the high pressure cylinder, the valve passes above the ports (see Fig. 2), and opens communication from the working end of the cylinder, viz., the space above the piston to the space below it, which is called the high pressure receiver: but which is equally a steam chest for the intermediate cylinder.

During the up stroke the steam is simply transferred from one side of the piston to the other; the whole cylinder, including the "working end," at that time forms part of the receiver. When the next down stroke commences, the steam in the high pressure receiver is passed into the intermediate cylinder. It enters the hollow piston rod again from the receiver by the ring of short, square headed holes shown, and passes from the piston rod to the cylinder by the ring of ports shown just above the intermediate piston. Cut-off, in this case, is given by the square headed ports passing into the gland in the intermediate cylinder cover, and so losing the supply of steam from the high pressure receiver or intermediate steam chest. The cycle is exactly the same as already described for the high pressure cylinder, and at the end of the second revolution the steam fills the intermediate receiver. Thence, in the third revolution, it passes into the low pressure cylinder, and in the second, or exhaust, half of that revolution, it passes from the low pressure cylinder, viz., from its upper end to the lower end, without material change of volume or pressure. It is only during the first half of the fourth revolution that it finally passes away from the "transfer chamber," the latter being in permanent communication with the condenser. The full cycle thus described is that of a triple expansion Cornish engine. In each separate stage of the expansion the complete Cornish cycle can be traced, and it is evidenced by two separate diagrams from the upper and lower end of each cylinder. The diagram from each receiver, or from the "transfer chamber" represents (as in every Cornish engine) the removal of back pressure on the down stroke, forming a virtual addition to the diagram from the upper end of the cylinder.

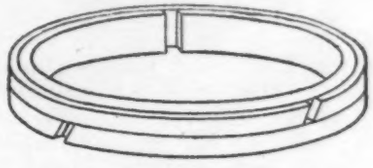


FIGURE 3.—THE PISTON RINGS.

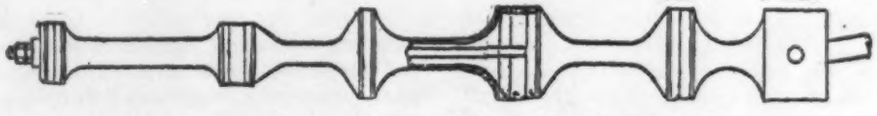


FIGURE 4.—A LINE OF WILLANS VALVES.

One of Mr. Willans' latest improvements in his engine was the system of packing rings shown in Fig. 3.

A complete line of valves (from a compound engine) is shown in Fig. 4. The piston valves are not steam packed. They are separated by suitable cast distance pieces with their ends faced to lie against the rings. All are strung together upon a steel tie rod, with a kind of spring washer under the nut at the end.

The gland rings, used instead of stuffing boxes, are shown in Fig. 5. They are upon exactly the same sys-

tem as the main piston rings; they are simply piston rings pressing inward instead of outward and guarded against end play in exactly the same manner. Steam is admitted behind them as in the main pistons.

The water above each piston is swept downwards by the exhaust steam into the space below during the whole of the exhaust stroke; it has not to be carried by the piston to the top of the cylinder, and then driven out suddenly through the port in a more or less

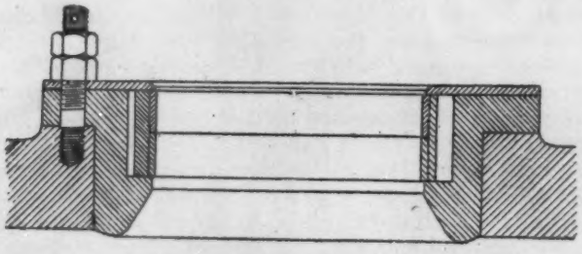


FIGURE 5.—STEAM GLAND BOX.

upward direction, as is the case in other forms of vertical engines. The Willans engine has therefore unique advantages in getting rid of water from the cylinders, apart from the action of the relief-valves.

Reference has been made to the fact that the connecting rods, and all the moving parts, are constantly in compression—a condition rendered possible only by the fact that the pistons are single-acting, giving no pull to the crank upon the up-stroke, but only a push upon the down-stroke. In any engine running at high speed, however, the moving parts can only be kept in compression upon the up-stroke by very powerful cushioning, which is rarely obtained in other high-speed engines without excessive compression in the cylinders, involving wasteful use of the steam. Sometimes, when a high speed engine exhausts into a vacuum, sufficient cushion cannot, by the usual means, be obtained at all. In the Willans engine very little compression is given in the steam cylinders, for little or none is required; the requisite cushioning is obtained independently by special means, the subject of a separate patent. It is in fact provided, without the addition of a single moving part to the engine, by the guide pistons. These on the up-stroke, compress the air contained in the guide cylinders, and thus any desired amount of cushion can be obtained according to the clearance allowed. The work expended in compressing the air is given out again by the expansion on the succeeding down-stroke, and the loss, when the engine is running at good speed, is proved by indicator diagrams to be too minute to be worth consideration (as shown in diagram on page 46.) There are holes in the guide cylinders, which are uncovered by the guides at the bottom of the stroke. As the casing or chamber which surrounds the guide cylinders and forms part of the framing of the engine is open to the atmosphere, it is evident that the air compression always commences at atmospheric pressure, and is constant and invariable in its results, whatever alteration may be made in the destination or the pressure of the exhaust steam.

In the low-pressure cylinders of all engines, and in the high-pressure cylinders if large enough to be so treated, internal relief valves are fitted, consisting of a gun-metal plug screwed into the top of the low-pressure cylinder. The plug is pierced by holes, covered by a single thin gun-metal disc. When the disc is raised, there is free communication between the cylinder and the receiver or steam chest above it. It is kept down under ordinary circumstances by the excess of the receiver pressure over that in the cylinder; therefore no spring is required, and there is no part liable to get out of order. If from water in the cylinder, or any other cause, the pressure rises above that in the receiver, the valve lifts, and though the water is only passed back into the receiver, the relief is found to be sufficient, and in fact far more effective than that given by ordinary external relief-valves. Engines so fitted have been tested by discharging a cubic foot of water suddenly into the steam-pipe; also by connecting the steam-pipe with the water-space of the boiler (by a half-inch pipe, with a difference of 80 lbs. between the pressure in the boiler and that in the steam-pipe)—without any injury to the engine in either case. In cases where internal relief valves cannot be used, ordinary external valves are fitted. Relief-cocks are also fitted upon the guide cylinders, in order to avoid compressing the air in them when the engine is being turned by hand, and to facilitate starting.

All these points—viz., the special piston (and valve and gland) rings, the special arrangements for drainage, and the use of the "Cornish cycle" in all stages of expansion—are of great importance, and are peculiar to the Willans engine.

The line of piston valves is driven by an eccentric on the crank pin. It is necessary that the source of motion for the valves should itself move up and down with the pistons, since the ports which have to be opened and closed also move up and down. There is an eccentric rod, which takes on to a hardened pin in a valve guide piston; the latter works in a bored guide formed inside the main guide piston.

There are two connecting rods to each line of pis-

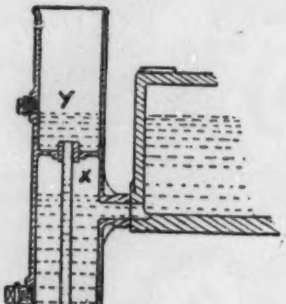


FIGURE 6.—THE LUBRICANT GAUGE.

tons, one on each side of the eccentric, the eccentric rod plays between them. The cranks and all working parts, except the cylinders and valves, are lubricated by the splash of the cranks in the crank chamber, where the lubricant usually consists of a mixture of oil and water. The guides and the pins at the upper ends of the connecting rods and eccentric rods are readily reached by the splash. The cut-off in the high pressure cylinder is effected by the movements of the ports in that part of the hollow piston rods which projects into the steam chest. The engines can be fitted with variable expansion gear when desired. If an early cut-off is desired, the gland is raised a little by packing pieces between it and the cylinder top. In that case the ports enter the gland earlier, and the steam is cut off earlier.

Fig. 6 shows the lubricant gage. The part X, acts as an air vessel, to prevent violent oscillation of the surface at Y. Since the gage communicates only with

the lowest part of the crank chamber, very little oil passes into it, and any overflow which takes place from Z consists almost entirely of water. The gage enables the quantity of lubricant in the crank chamber to be easily ascertained at any time.

It is the Willans engine that "Machinery," one of the most conservative of the technical journals of London, states: "It is impossible to speak too highly of this type of engine as an efficient and economical prime mover. The manner in which it is constructed is worthy of all praise. On former occasions we have

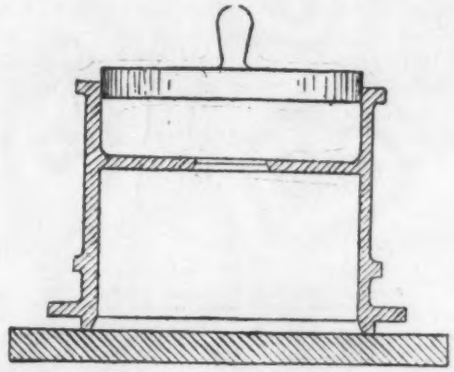


FIGURE 7.—TEMPLATE SUPPORTED IN CYLINDER BY AIR.

discussed some of the difficulties of making interchangeable parts. At the Thames Ditton Works all the difficulties have one by one been surmounted, and it is believed that few engines are manufactured with such care respecting the accuracy of the machine work and the soundness of the materials employed as the Willans engine. It will be noticed that the engine is mostly composed of turning and boring work, the kind of workshop tooling we all seek to employ to as large an extent as possible in our designs."

The English practice of operating central stations has been largely based upon the perfection and almost universal adoption of the Willans central valve, and one of the most striking features of central lighting stations equipped with central valve engines is the arrangement of a line of combined engines and dynamos of 100, 200 and 300 h. p. units, coupled up in parallel, so that all but one of the engines are loaded to their full capacity, while the one partially loaded engine (all of the other governors having gone out of action) is doing all the governing. In other words, it takes care of all variations or fluctuations of load within the limit of its capacity. For instance: Calling at any one of the numerous central stations using Willans engines (in London) at about 10 o'clock at night the visitor will find the complete plant of ten or more engines coupled direct to the dynamos, running with not more than two attendants—an engineer who looks after the engines, and an electrician to take care of the switchboards. Of these ten engines, nine would be loaded to their full capacity so that the governors have gone out of action, while the tenth engine will be running with a light load—possibly one-half its capacity—thus being in position to take care of the fluctuation of the load, as lighting districts were thrown on or off. When the load decreases about 11 o'clock so that the second or No. 9 engine will not be loaded to its full extent, No. 10 is shut down, and No. 9 will do the governing, until later in the evening, when the load being removed from No. 9, that engine will be shut down and No. 8 will take up the duty of governing, and so on, engines being shut down from time to time as the load decreases. This system has great flexibility, and possesses many advantages over the ordinary system of making each engine automatic in its action, and compelling it to take care of certain sections or districts with all its variations of load, for it is a well-known fact that there is as much waste of power in running an engine and dynamo underloaded as there is in overloading.

For central station work the use of the central valve engines with direct coupled dynamos permits the use of smaller units than is ordinarily used in central stations; this, of course, decreases the first cost in the purchase of relay outfits, for it is obviously cheaper to purchase a 100 or 200 h. p. unit than it is to buy a 500 or 1000 h . p. unit, and when a number of them are coupled up in parallel, a majority of them can be worked at full load, which is the most economical condition for both engine and dynamo. At the same time one engine is taking care of the fluctuations of load, thus confining the governing of the plant within a smaller range between full load and no load than it is possible to do with other systems. In some English stations this point of economy is carried out to such an extent that where they are using 200 or 300 h. p. units they use a 100 h. p. engine for a relay, and another of the same size to do the governing for the large units.

This peculiarity of English stations is fittingly exemplified in the St. Pancras electric lighting station at Regents Park, London, the interior of which is illustrated on page 37. From tests made by Prof. Robinson to determine the efficiency of the plant it was found that with a load of 680 amperes at 118 volts, the steam consumption was 18.65 lbs. per electrical horse-power, working condensing and with dynamos separately excited, the boiler pressure being 173 lbs. and the boiler evaporation being 9,747 pounds of water per one pound of coal. This gives a consumption of 1.91 lbs. of coal per electrical horse-power per hour, an efficiency rarely attained in steam plants.

The "London Electrician" of February 2, 1894, contained a communication from Messrs. Siemens Bros.

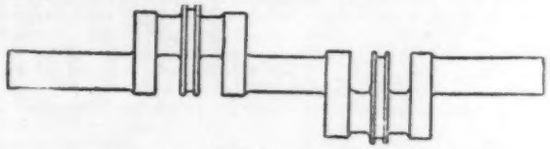


FIGURE 8.—A WILLANS CRANK SHAFT.

& Company, Ltd., in which reference was made to tests made by Prof. Kennedy, consulting engineer, on a Siemens-Willans set for the Glasgow Corporation. "We venture to think," wrote Mr. Al. Siemens, Director, "that the figures in the enclosed table are of some interest as to the best of our knowledge, so high an efficiency as 88 per cent, has not been previously obtained. The curve which we enclose is also remarkable." This is reproduced on this page, and the results of the test are shown in the following table:

Load	Pressure in Steam Chest	Revolutions per Minute	Amperes	Volts	I. H. P.	E. H. P.	Water per E. H. P. lbs.	Efficiency Per Cent.
Full	139	346	1001.0	225	343.0	302.0	23.08	88.04
¾	112	347	740.0	225	262.0	223.2	27.01	85.11
½	88	344	515.0	225	197.2	155.3	31.63	78.76
¼	56	345	236.6	225	112.2	71.2	47.09	63.44

On page 40 also appears the efficiency curve of the Walker generator now in operation in the Pacific Pow-

er plant, which evidences the excellence of the equipment.

It is interesting to note, in addition, the results of tests made by Prof. Unwin, F. R. S., on a triple expansion, 40 h. p. condensing Willans engine, the results Institute of Civil Engineers, London, as follows:

Barometer, lbs. pressure per square inch	14.58
Steam chest pressure from gauge (absolute)	184.58
Condenser back pressure	0.75
Mean admission pressure absolute	175.
Revolutions, total during trial	69.420
Duration of trial, minutes	180.93
Mean revolutions per minute (actual)	383.7
Total mean pressure referred to L. P. Cylinder	34.87
Indicated Horse Power	29.84
Discharge from hot well per hour	380.3
Water per I. H. P., hour	12.74

An examination of the Willans-Walker set in operation at the works of the Pacific Power Company impresses one immeasurably with the perfection of the combination. The apparent absence of any moving part whatever except the governor wheel, the armature and a small portion of the shaft, and as well as the noiselessness of running, reminds one of a direct-connected water wheel plant, except that the steam plant makes even less noise than the water plant. Not a motion or a steam carrying part is visible and practically no heat is radiated therefrom, which of course increases economy. At the Pacific Power plant the Willans-Walker has been in continuous service from Sunday afternoon to Sunday morning each week since its installation, six months ago, and, in fact, the plant was installed for just such service and judging from the records of similar equipments, it is safe to predict that it will be capable of continuing under similar use for years.

In conclusion it may be stated that the installation of five other Willans-Walker sets similar to the present one has been determined upon and, in fact, the foundation for the second set has already been erected. This will give the Pacific Power Company a nominal capacity of 3,000 horse power and the plan of installation closely resembles that of the St. Pancras

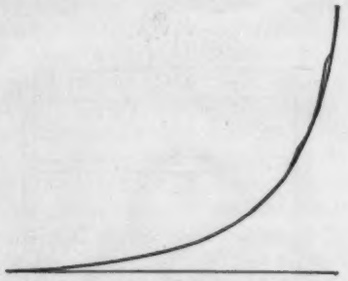


Diagram taken from air-cushion cylinder of the Central-valve Engine, direct coupled to general Electric Co. Multipolar generator.
FIGURE 9.

vestry station previously described. The work of construction has been carried out in a most thorough manner by the Abner Doble Company, agents for both the Walker and the Willans equipments and who have throughout acted in conjunction with the Pacific Power Company in the execution of the engineering details of this interesting and most efficient plant.

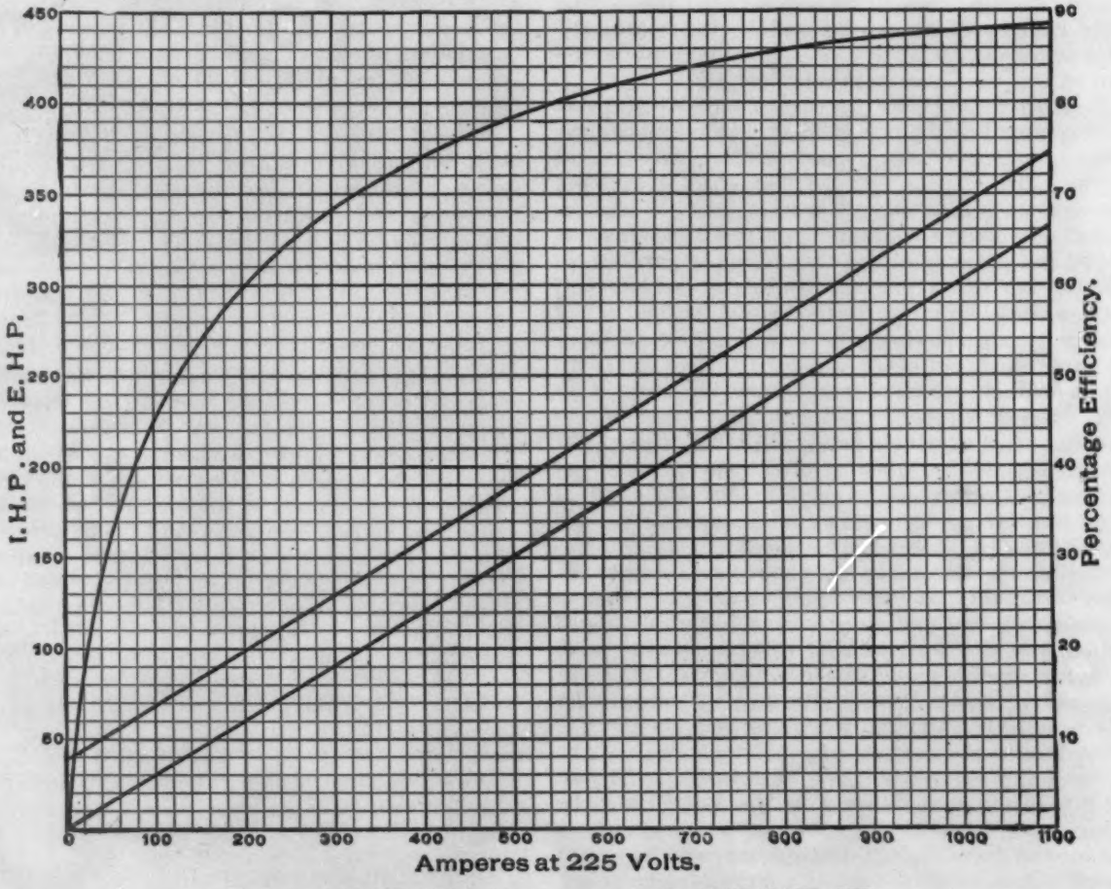


FIGURE 10.—EFFICIENCY CURVE OF A SIEMENS-WILLANS SET.

Mining

ARE MINERAL LODES OF ELECTRICAL FORMATION?

By Sidney Sprout.

Whether the souls of the departed remain on earth after death will probably forever remain a disputed question, but it is certain the fruits of the minds of some do so remain in the forms of writings.

It was thus that there recently came to the writer the ideas of one in the form of a book written by a long since forgotten civil engineer named Hopkins, who lived in the early part of this century and in this work the author attributes the deposits of metals in quartz ledges to the action of the earth's magnetic lines of

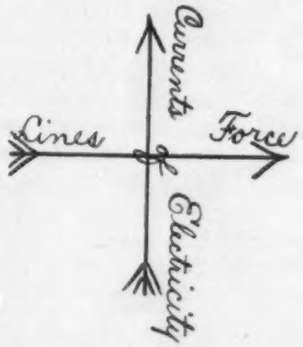


Figure 1.—THE RELATIONS OF ELECTRICITY AND MAGNETISM.

force, giving in addition, very interesting descriptions of his ideas of geological formations. He theorizes clearly how the quartz formation is of water origin, instead of in accordance with the well advanced theory that quartz owes its formation to molten material being forced up through the fissures of the rock. The latter idea, of course, follows the now disputed theory that the earth is a body of molten matter with a thin crust of cooled material forming its surface, but whether the former or the latter theory is correct is not of necessity to be discussed now, but for the present we will accept the theory favoring the water formation of quartz.

Hopkins' book was praised very highly by its owner, Mr. Almarin B. Paul, M. E., who secured it years ago and who has reason for believing it to be the only copy of the work in the United States. Up to the present time it has been but hastily glanced through, but this cursory perusal has suggested an effort to continue the theories advanced by the author.

Although the laws and principles governing magnetism and electricity are now well understood and form one of the leading sciences of the present time, it must be remembered that those connecting electricity and magnetism are of comparatively recent date, and while the author describes some experiments with the galvanic battery, they are insignificant in comparison with present methods of electro-magnetic measurements and manipulations. Hopkins' work, therefore, was not appreciated during his day, probably because his theories were too far advanced for the times and possibly because he was himself not able to satisfactorily explain them. His book at least does not make the subject clear in the light of the present, but could he have lived at this day there is no doubt but that he could have given a very definite and substantial theory of the electro-deposition of metals in the earth's fissures. The ideas gathered from Hopkins' book form the basis for the following:

One of the most difficult matters to explain to a person having no knowledge of the principles of electricity and magnetism is the distinguishing features of the two forces, but it is easy to remember that wherever magnetic lines of force and currents of electricity exist, the former invariably crosses the latter at right angles, or vice versa. This is shown in the dynamo in which the magnetic lines of force pass from field to field, cutting the armature wire at right angles and inducing in it a current of electricity, which is also at right angles to the magnetic lines of force. When this is understood, next consider the earth itself, which, as every one knows, is a huge magnet, in which the magnetic lines of force run from pole to pole, parallelling the geographical line of longitude. It naturally follows, therefore, that as the magnetic lines of force in the earth extend in a northerly and southerly direction, the currents of electricity will be at right angles to them, or mainly in an easterly and westerly direction. The mariner's compass proves the existence of magnetism in the earth, and every telegrapher can relate experiences demonstrating the occurrence of earth currents of electricity.

To advance another step; if the terminals of an ordinary battery be immersed in any metallic solution such as sulphate of copper, metal will be taken from one wire—the positive one—and transmitted electro-chemically through the solution and deposited upon the negative wire. This phenomena embodies all there is to the physical principle underlying electro-plating and the electro-deposition of metals, and wherever a current of electricity traverses a path moistened with a solution of any metal, the deposition of that metal is bound to take place. It must be clear that the earth is a huge dynamo, revolving in a weak magnetic field and generating internal currents of electricity that, though of low potential, are of enormous volume because of the immeasurably low resistance of

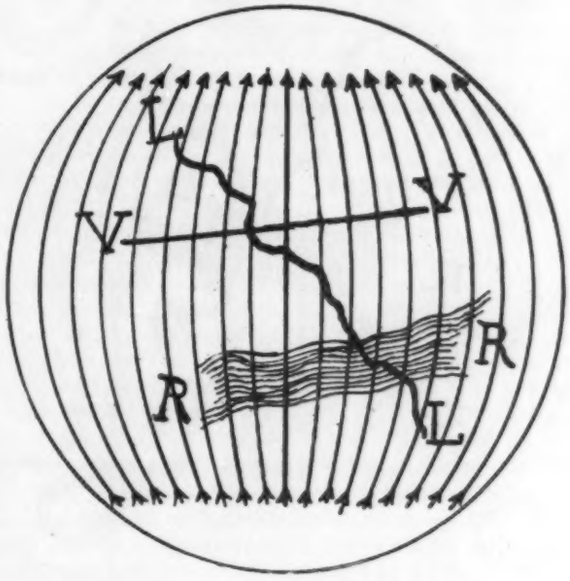


Figure 2.—THE EARTH AS A DYNAMO.

the conductor traversed, namely, the earth itself. When it is understood that it is the ampere that causes the precipitation of metal in the deposition bath, and that the volume of earth currents must reach millions and millions of amperes which have been flowing through the countless ages of the past even from pre-geological times, it will be seen that the theory which attributes the existence of metal in the earth's crust to electro-deposition can not be attacked on the ground of physical impossibility.

Such enormous currents of electricity flowing transversely around the world must necessarily seek out every possible path and as the resistance of different portions of the earth's crust vary materially according to its compositions, paths of current flow are selected according to the channels of least resistance presented, for, in electricity, the shortest path is the path of least resistance. Though the trend of current flow is parallel to the equator, its actual course varies in different locations because of the existence of fissures and strata of metal bearing rock. These fissures or ledges run in all directions and depths and all serve as conductors of earth currents, but for convenience, assume as in Figure 2, that L L is a crevice in the earth's surface, extending through the formation of metal bearing rock R R. and the vein of, say, iron ore, V V. If the fissure L L is filled with or contains a solution of gold in whatever quantity (as in ocean water, for instance),

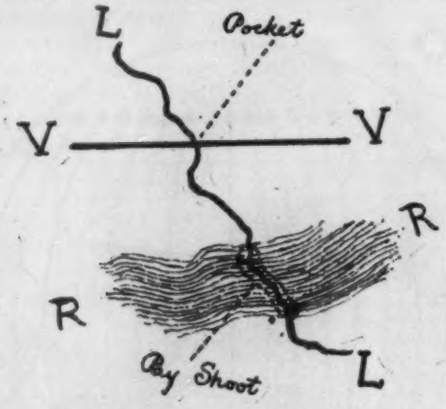


FIGURE 3.—A SUGGESTION ON THE FORMATION OF "POCKETS" AND "PAY SHOOTS."

it will be found that the earth currents will take the paths afforded by R R and V V, depositing the gold held in solution in the fissure L L. From the time of the creation this electro-deposition process has been going on until the fissure has become filled with crystals of the solution, interspersed with deposits of gold. As water presses against the sides of a vessel when crystallized by freezing, so do these crystals become forced together under such enormous pressure as to change their form from that of crystals to that of quartz. Sometimes the action of the pressure is such as will grind the gold to small particles; sometimes grinding does not occur, when the deposited gold remains as a free vein; again, if the sides of the fissure are soft, or if they ever were soft, the deposit of gold grows larger and larger and a "pocket" of gold is formed at the intersection of the fissure L L and the vein of ore V V, as seen in Figure 3. If on the other hand, the deposit occurs at the intersection of the fissure L L and the formation of metal bearing rock R R, of a moist nature, a good "pay shoot" will occur as in Figure 3.

According to this theory, if a ledge runs north and south (or nearly so), and is crossed approximately at right angles by, say, a vein of iron ore, one may expect to find at the intersection a "pocket," while, if it crosses a strata of metallic rock, the intersection will probably prove to be a "pay shoot."

The writer, not being familiar with mining, can not say that these are the conditions as mining engineers find them, but feels that the idea may bring out the views of those interested, possibly with the result that new and more efficient methods of locating deposits of metal may be adopted which will prove to be more certain and far less costly than the present mode of sinking expensive shafts or boring experimental tunnels.

Personal

Dr. F. A. C. Perrine and family are spending the summer at the home of his parents in Freehold, N. J.

Mr. F. V. T. Lee, of Stanford's '97 class in electrical engineering, has become associated in the engineering, staff of Mr. Jno. Martin, Pacific Coast agent of the Stanley Company.

Mr. Leon Porsh, one of the pioneers of Edison installation, has returned to San Salvador, Central America, after a visit of a month or more in San Francisco. His exceptional ability as an installing electrical engineer has won a very lucrative business for him in that city.

Mr. C. C. Chesny, of the Stanley Electric Manufacturing Company, and who has won fame and fortune through the "S. K. C.," (Stanley, Kelley, Chesny) system of that concern, has spent a fortnight in San Francisco visiting the various transmission plants in California and returned East on June 16th.

Mr. W. Stuart Harrison, electrician for the Oriental Telegraph Company, with headquarters at Hong Kong, passed through San Francisco last month en route for London, whither he goes for a period of rest and recreation. The week spent by Mr. Harrison in San Francisco won for him many friends who look upon his brief sojourn here as a rudeness of fate in that it was so very short.

CENTRAL CONDENSERS.

There is a growing tendency in some large power-plants to introduce condensers of the so-called "central" type, one large condensing apparatus being used to maintain a vacuum into which all the various engines, pumps and compressors discharge their exhaust steam. This central condenser has its own air and circulating pump, and forms a sort of negative generator at the opposite end of the power chain from the boiler, with a steady "pull," so to speak, upon all the motors in the establishment. Apart from the general economy of the use of a condenser, "central" condensers possess the additional advantage that a great number of small engines, pumps, and the like, which, in ordinary plants, would be puffing and barking away into the atmosphere, are operated, condensing as a matter of course when there is a general vacuum tank at hand. Such central condensers might be profitably installed wherever there is sufficient water available. —Cassier's Magazine.

Hydraulics

THE GOVERNMENT OF WATER POWER.—I.

By Mark A. Replogle, Engineer.

The regulation of the speed of a water-wheel in a power plant is determined by four distinct factors:

1. Changes in load or requirements for power;
2. Time required for gravity to generate power;
3. Capacity of the plant for stored energy; and,
4. The governor or mechanism that should automatically combine the above three factors in such a manner as to obtain even speed or good regulation.

These factors, clearly defined, are bases from which intelligent calculations can be made showing the possible efficiency of government in any water-power plant.

Let it be understood that the word "government" refers to that regularity of motion or speed that is so desirable and necessary in our finest manufacturing and electrical power plants. Absolutely uniform speed can be maintained only when there is no change in the power supply and no change in the friction or work of the plant; but if the above factors are carefully considered and judiciously manipulated or applied, the variations of speed may be so reduced that the results can be called perfect government.

The speed of a plant at all times is a resultant of opposing forces establishing an equilibrium or balance. The power supply has a tendency to increase speed and the work has a tendency to decrease it. Speed may be varied by increasing the power supply or by decreasing the power supply; by increasing the amount of work performed, or by decreasing the amount of work performed; and any one of the above changes causes instantly a change in the speed; but the amount of change in speed depends entirely upon the amount of change in load, the time it takes gravity to generate power, the quantity of energy in store, and the operation of the governor in opening or closing gate.

Since it is impossible for any automatic governor to change the power supply at the instant a change has been made in the load or work of a power plant, it is very plain that there must be fluctuations in the speed. The problem of government is to narrow these fluctuations to such an extent that the speed will be constant as far as practical operation is concerned. The finest government ever obtained consisted of changes in speed, but within narrow limits. The speed of a well governed single-crank engine changes four times every revolution.

The first factor in governing, "the changes in load," is a variable one, and is limited only by the character of the work done by the water-wheel. The changes may range from zero to the full power of the wheel instantly, making government a more difficult problem than it would be if the changes were limited in number or quantity. It is plain that if an even speed is retained when a change in load is made, there must be at the same instant a corresponding change in the power supply. This is an impossibility in automatic governing, for several reasons: the speed must change in order to inspire the speed governor; following this, the speed governor causes the valve or gate-moving mechanism to operate, which operation requires time; and again, it requires time for gravity to overcome the inertia of the increased quantity of water that must pass through the wheel before an increase in power can be had. During all this time, the speed of plant has been decreasing if the load was increased, or increasing if the load was decreased, and the amount of change in speed depends entirely upon what ratio the change in load bears to the stored energy in the moving parts of the plant. A heavy change in load will of course cause a greater change in speed before the power supply is changed, than a light change in load. The problem is, therefore, to proportion properly the power storage to the changes of load that must be imposed upon the plant, because this power storage, or the capacity to store power, must take care of all changes in load until the power supply, or gravity effects, can compensate for said changes.

The second factor, "time required for gravity to generate power," is more constant than the first. In fact, the limits are established in the construction of the water-power plant, and, of course, remain so. The point we wish to emphasize most in the time requirements is the inertia and momentum effects of the water.

A locomotive can propel a train of cars at a rapid speed; but it takes time to acquire such speed. When the locomotive has brought enough pressure to bear upon the train, it moves, at first slowly, but keeps increasing in speed often many seconds before it reaches full motion. The locomotive may be limited in strength to 250 H. P. per second. The train in full motion may represent 25,000 H. P. for a second. In such case, it will take the locomotive 100 seconds to bring the train to speed if we do not consider the frictional losses. Water has no power in itself; but must be put in motion by gravity in the same manner that the locomotive starts the train of cars, and a long train of water acted upon by a constant gravity effect, is put in motion in the same manner that the train of cars is by the locomotive. It is plain, then, that the time element must be considered in the government of water-power. The water-wheel cannot furnish power until it brings to rest the water to which gravity has given motion, and it can receive no power from the water until the water has sufficient motion for the moving wheel to retard. It is also plain that there must be changes in the flow and velocity of water for every change made in the load of the water-wheel; also the change in the flow of water must occur before there can be a change in the power supply.

It is well known that water has practically no elasticity; hence, if enclosed in a long pipe, the whole body must be put in motion at the same time. If the pipe or flume consists of several hundred feet of horizontal length and only a few feet of vertical pipe or "head" which alone gives gravity effects on the wheel, it is a similar proposition to the locomotive and train of cars. It is very evident, then, that long horizontal pipes should be avoided in order to reduce to a minimum the time required to get gravity effects, because the speed of water-wheels will keep changing, after a change in load, until the effects from gravity can correct it in the power supply.

Gravity effects at best are very slow as compared with steam, and for this reason a water-power is handicapped in the matter of government. The logical conclusion is, that in water-powers the water or power supply should all be under the direct action of gravity and move in line with it. This reduces the time necessary to furnish increased or decreased power, to the shortest limit.

THE JOURNAL OF ELECTRICITY.

An Illustrated Review of the Industrial Applications of Electricity, Gas and Power.

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FOR TABLE OF CONTENTS SEE PAGE 60.

EDITORIAL.

A FAVOR SOLICITED.

It is difficult to gauge the value of the service rendered to an advertiser by a periodical for the reason that its publisher has no means for determining the amount of business that an "ad." brings. The advertising pages of a paper hold the position of a solicitor for business, but the advertiser is the only party to the contract who has any facilities whatever for approximating the amount of business brought either directly or indirectly by any particular advertising medium, and even his facilities are closely restricted for it is not a rule that he knows the source from which an order is derived.

It is important to the advertiser that he learn the value of each advertising medium and it is of double importance to the publisher that his publication should receive the credit for any and all inquiries or orders given through his medium.

A very simple favor then is asked of all, viz., will you kindly mention "The Journal of Electricity" in writing to the advertisers in its pages.

It costs you nothing and it renders both advertiser and the proprietor a highly valued service.

A NOVEL ENDORSEMENT.

In these days of cleverest competition, the best man wins provided his prices are lowest and his qualities are highest, but rarely are these requisites combined in so novel a manner as occurred in the recent awarding of the contract for the electrical equipment for the Southern California Power Company. The installation is one of extraordinary note as this initial plant is to consist of four 1,000 horse power, 1,000-volt generators, feeding step-up transformers which deliver current to the line at 33,000 volts for transmission to Los Angeles, 81 miles distant.

The bidding was confined to three companies, one, of which the Stanley company, has made a specialty of the development and perfection of inductor generators. The buyer, who installed the first three phase plant in the country, has had long experience in transmission work, and steadfastly maintained the opinion he had formed of the superiority of the inductor type over rotating field generators, and the award was conceded to the Stanley company when the two remaining companies captured the prize by modifying their bids so as to install inductor type apparatus at the figures already submitted for less recent forms of equipments.

Thus did the Stanley company lose the contract, but it is doubtful if the pecuniary loss it suffers will not be returned to it a hundred fold by this, the most radical and far-reaching endorsement which any electrical company in America has ever been forced to give the ideas of a competitor.

THE BERLINER CONSOLATION.

The attention of a great portion of the electrical fraternity of the country is at present wrapped up in a consideration of the probable effects of the recent decision of the Supreme Court of the United States,, which held that Berliner did not obtain the notorious transmitter patent of November 17, 1891, by fraud. The decision observed that "a wisdom born after the event is the cheapest of all wisdom" and so, now that the court's findings have appeared, it is looked upon as a simple case and one upon which the court rendered a most righteous verdict, for without a particle of evidence, either direct or indirect, supporting the allegation, how could the charge of fraud be sustained?

It is simply justice that in every instance the burden of proof shall fall on the accuser, hence those who feel instinctively that fraud has been practiced by the American Bell Telephone Company, one way or another, in the matter of the Berliner patent, have no recourse at law but they are nevertheless privileged to their own opinions. These people too, and there are legions of them, intuitively feel that the whole affair which called forth the late Berliner decision, was a supposititious suit—that it was conceived in sin and born in iniquity; that the sin was that of artful machination and the iniquity, that of illegitimate profit. Of this there is of course no evidence extant, not a "scintilla" as the court has said, but many will, nevertheless, feel a moral conviction that assumptions long this line are well grounded.

The facts of the case are that the Court did not pass upon the question except the allegation of fraud in the issuance of the patent, hence its validity is yet undetermined. Moreover, the present attitude of the Bell Company seems to indicate that it proposes to prevent if possible, the adjudication of the validity of the Berliner patent, evidently fearing an adverse outcome and believing that the patent will render greater service as a bogy than as a bludgeon. The telephone

situation may be epitomized as a struggle between the popular bent and an astute corporation, wherein the former is simply battling for its right of existence. The expression "its right" is used as there is every reason to believe that the courts will nulify the patent, particularly because of the expiration of the English patent on January 8, 1894, as provided under Section 4887 of the revised Statutes.

A further evidence of the lameness of the Berliner patent is developing in the attitude of the only electrical periodical that has been charged with being the official organ of the American Bell Telephone Company, namely, "Electrical Engineering." This paper which has steadfastly sustained the monopoly and as steadfastly discouraged opposition enterprises, has, since the rendering of the Berliner decision, stooped to the vituperation of a leader of the independent telephone movement, Mr. James E. Keelyn, President of the Western Telephone Construction Company of Chicago. The decadence of "Electrical Engineering" from its original high plane of excellence in technical literature, to the indesputible bias and rancor of its present editorials on the telephone situation is lamentable, but it is not so noteworthy as is the evident extremity of the Bell Company, which thus finds personal abuse a weapon necessary to its warfare.

The decision of the highest tribunal in the land on the question of fraud has afforded a measure of consolation and solace to the Bell Company, but when the Court acts on the validity of the Berliner patent, then will come a winter of discontent for this most crafty of corporations.

ENGINEERING DIFFICULTIES IN CHINA.

That difficulties of practically an insuperable nature beset the introduction of many engineering enterprises in China is not doubted by those familiar with the situation in that far-off country and it is an oft-told tale that one of the greatest set-backs of this nature is the fanatical superstition of the natives who check if not actually prevent the erection of poles and wires because of the unholy shadows they cast. Each traveller knows of this superstition and vouches for the obstacles it presents, but as the devout Chinaman does not object to shadows falling on the earth provided it does not defile a spot under which moulds the bones of a departed friend or kinsman, there is a way out of the difficulty as the existence of telegraph and telephone companies shows.

The accursed custom which poles have of casting blighting shadows will probably not prove so great a barrier to the introduction of electric railway enterprises will the combined opposition of the telegraph and telephone companies which, owing to their priority, perpetrate a dog in the manger policy rather than reconstruct their systems so that disturbances from railway return circuits will be prevented. Transmission projects, too, will probably meet like opposition, and indeed the experiences have thus far been that the serious mention of a new electric railway enterprise in China brings from the companies named the intimidation that the installation of a railway or transmission or alternating current system will mean the giving up of the telephone and telegraphs, for, they say, it is impossible for both to be operated in the same territory. The citizens of enlightened countries wherein each city of importance contains practically every commercial application of electricity, each working without interference with the other, will recognize this as a rare specimen of corporate bosh, but it placates slow-going China and, in lulling it back to sleep, tolls the knell of another projected enterprise.

Assuming that an electric railway company, for instance, should sufficiently warm itself into the good favors of the numerous mandarins, who sway Chinese officialdom as best pleases their moods and purses, so that it could withstand the freeze-out sorties of the telegraph and telephone companies, and should, moreover, with ominpotent zeal, at last succeed in erecting its poles here and there so that the soul-blasting shadows from poles and wires ne'er could fall on grave or on house with sickness or prospective confinement, the ability thus far acquired might enable the building and operation of an electric road through the narrow tortuous rat-ways ycleped streets. In China, a two-foot passageway gives perfect satisfaction as an alley; if it have a width of six feet or so, it is dignified to a street, while ten feet is an avenue and twelve feet is a boulevard indeed. Considering the prejudice with which aristocricy the world over regards the defacement of its boulevards by the "unsightly" trolley, one must conclude that the railway system of a Chinese city will perforce, be relegated to its streets and avenues, where it would doubtless be beset by troubles distinctively its own. Then the density of the moving population that ceaselessly worms over each inch of every thoroughfare and the sacred funeral procession that insures the eternal happiness of the dead according to the measure of pomp and gorgeousness displayed, to the quality of the incense of burning sandal or odorous punk, to the quantity of smoking pig, of steaming rice and of garlicky chicken and to the volume of wail set up by the hired mourners! To obstruct the way of, or to cast a shadow upon, such a cortege would entail the eternal damnation of the dead and what could the poor street car man do?

Then again, human life is held in low esteem in China—except when the prospect of "blood money" exhorbitantly inflates its value. The sportsman who would shoot quail or snipe must look sharp lest his shot perforate the vitals of the mongol who rises as from the ground in front of the gun, courting death that his family may bleed the slayer for the life-long affluence of a settlement for five hundred dollars or so. With the "deadly trolley" abroad in the land of the Celestial, one may well stand aghast at the thought of the extent to which the mania for being

killed under its relentless wheels woud be developed there. Verily, the path of the street railway man in China is beset with entangling vines and vicious thorns and ragged rocks of unwieldly weights.

Some day the dawn of knowledge will break the blackness of the polar night that has ever enveloped China; then in the bright sunlight of civilization will awaken its millions upon millions of people and warm into life and usefulness its mighty, though dormant, resources. Until then, it does not appear that the Flowery Kingdom will hold forth any Utopian inducements either to foreign labor or to foreign capital.

Passing Comment

An Editorial Review of Current Events and Comtemporary Publications.

SHALL PLANT COSTS CONFORM TO FUEL COSTS?

Power station engineers will not be slow to grasp the significance of the idea which led Mr. R. J. Hill, Chief Engineer of the Chicago City Railway, to install simple non-condensing engines, instead of compound or condensing engines, and rope transmission drives instead of direct connected generators in the new power house of that company. This is to be the largest electric plant of its kind in the country and is fully described in a late number of "Power", which points out that Mr. Hill, after a thorough canvass of other stations and a study of the results obtained, concluded that at the present relative prices of fuel and machinery, a better ultimate efficiency would result in this particular instance by adopting a plan of installation which, on its face, looks like ignoring the improvements and developments of the past decade.

Whether Mr. Hill's expectations of being able to run the plant at greater economy are to be realized remains to be seen but this much is certain that the mania for burdening a plant with high-priced machinery for the sole purpose of economizing low-priced fuel is liable to be carried to an unwarranted extreme. There is much to be said on the question, both pro and con, and the outcome will be awaited with unabated interest by the engineers of those communities blest with cheap coal, and should Mr. Hill be wrong in his convictions, which seems to be very improbable, he will nevertheless have won for himself enviable distinction as a deep-thinking engineer with rare courage to execute his bold convictions.

A MANUFACTURER'S RIGHTS UPHELD.

American manufacturers will feel more than usual interest in the decision recently rendered by an English court, under which the firm of Sugden, Pound & Wagner, former selling agents for the Magnolia Metal Company (of New York) in Europe, and which traded under the name of the Magnolia Anti-Friction Company of Great Britain by special permission of the parent company, has been dispossessed of the agency and, together with other persons and concerns, have been perpetually enjoined from continuing the fraudulent business of making an anti-friction metal and branding it with the trade mark of the Magnolia Metal Company of New York, imitating its ingots, marking the boxes in which the metal is packed: "Made in the United States," and otherwise deceiving and imposing upon purchasers of anti-friction metal in Great Britain and Europe. The appeal taken from the injunction referred to, was tried before the Court of Appeals, Lord Esher presiding, and the perpetual injunction granted by Justice Collins was confirmed. It was in this trial that Lord Esher denounced the action of the parties above named and characterized their performances as "a disgusting fraud."

The piracy which leads not only to the appropriation of a trade mark, but also to the wholesale manufacture and sale of a spurious product under convincing representations that it is the genuine material, cannot be too strongly condemned and now that the English Courts have declared that justice must prevail, the suits which have been brought by the Magnolia Metal Company in American Courts against infringers will give wholesome publicity to the wrongs that American manufacturers suffer at the hands of foreign as well as domestic competitors.

LIQUID AIR AND POWER TRANSMISSION.

That man is only upon the threshold of some of the sciences is evidenced by the points brought out by Mr. Edward A. Rix in the conclusion of a lecture delivered to the engineering students of the Leland Stanford, Junior, University on May 3rd last, and which is reproduced on another page of this number, concerning experiments with liquified air or "aerine," as the lecturer states it is to be called. The matter is best brought out in Mr. Rix's own words. After discussing the use of compressed air for mining purposes and attributing the commercial production of aerine to Mr. Charles E. Tripler of New York, more than twelve months ago, Mr. Rix proceeded to describe experiments recently made in his presence in New York as follows:

"I look upon the commercial production of aerine as a very important discovery, and I think the future question of economy in motive power is intimately associated with this liquid. Compressed air, at pressures ranging from 1,000 pounds upward, is conducted from an air receiver through a small pipe, is refrigerated to expel its moisture, and is then conducted into the apparatus which liquifies it completely, without the use of chemicals of any kind, and it flows from this apparatus in a stream about the size of a lead pencil (in the apparatus which I saw) into a glass insulated receptacle, containing about two gallons. I saw this

receptacle filled in a very short time. Of course, while in an open vessel aerine has no pressure, but its temperature is approximately—385 deg. Fahr. Inasmuch as it is boiling rapidly on the surface, owing to its absorption of heat from the atmosphere, it looks like carbonated milk on the surface, but upon dipping some of it out in a glass and observing its color through the glass, it has very much the appearance of ordinary water, and about the same weight. Its temperature is very deceptive, for as it runs from the condenser one may allow it to trickle over the fingers for a short space of time, and it appears to have the atmospheric temperature. The sensation is very much like pushing one's hand into a bag of feathers or into a mercury bath, allowing, of course, for the difference in weight between the mercury and the aerine. If, however, you immerse your hand in the liquid a sufficient time to establish a contact, the flesh would be burned, the same as if it were exposed to 440 degrees of heat, measured above the atmospheric temperature. If a test tube of 1½ inches diameter, having a couple of pounds of mercury in the bottom, is immersed in aerine, the mercury will be frozen solid in a few seconds, and may be hammered out and otherwise manipulated the same as lead. An alcohol thermometer of large size will be frozen instantly upon being immersed in the liquid, while it will take several minutes to thaw out the small bulb of this thermometer by covering it with the palm of the hand.

"A tablespoonful of aerine poured on about a fluid ounce of whisky will freeze it at once into flat scales, giving the whole the appearance and color of cyanide of potassium. This may be emptied out on a table and will remain frozen in that condition for fully five minutes. A teacupful of aerine poured on top of a tank of cold water goes into its spheroid state instantly in globules of about half the size of ordinary marbles, which fly around on the surface, leaving a trail of white vapor behind them. A handkerchief saturated with the liquid will be charred and destroyed as if it were put in the oven and browned, though no change of color is apparent. Its evaporation is quite slow and it may be carried about for a number of hours in an open vessel without entirely disappearing. It probably represents a compression of about 700 atmospheres and would therefore, in a confined space and at 60 deg. temperature, represent a pressure of somewhere from ten to twelve thousand pounds to the square inch.

"Just what aerine has to do with thermo-dynamics I must leave to conjecture at present, for I am not permitted to say, but I know of some and look for many other remarkable developments. For transmission purposes there seems to be no reason why aerine should not be pumped through an insulated pipe, the same as water. When this becomes possible, the diameters of pipes to transmit large horse-powers would be exceedingly small. For instance, inasmuch as one pound of air will yield, in properly reheated engines, about 1.6 horse-power, a thousand horse-power would require 620 pounds of air or aerine per minute. This 620 pounds would occupy a space of but ten cubic feet. The transmission pipe, then, would have to convey ten cubic feet per minute. Let us say the transmission is for five miles. It is easy to calculate from ordinary hydraulic formulae that a three-inch pipe would convey this power with a pumping pressure at the point of supply of 200 pounds. The only pressure which the pipe would have to resist would be the pumping pressure, consequently ordinary gas pipe or tubing could be used, the cost of which, together with its insulation, would be an insignificant figure in comparison to the horse-power it would transmit."

Literature.

Any Book Published Mailed upon Receipt of Price by The Journal of Electricity.

"A SYSTEMATIC TREATMENT ON ELECTRICAL MEASUREMENTS", by Herschel C. Parker, Ph. B., Tutor in Physics, Columbia University. Cloth 6¾ x 9¾ inches, 120 pages, 100 diagrammatic illustrations. Spon & Chamberlain, 12 Cortlandt St., New York, 1897. Price, $1.00.

The opening chapter of this handbook gives a classification of electrical measurements that suggests the scope of the work and sets forth the different methods available for the determination of any form of current or circuit value. It takes no cognizance at this place of instruments used, but instead presents a graphic scheme in classified form which shows at a glance the various modes for measuring all degrees of resistance, electromotive force, current, capacity, and inductance. This by no means, however, exhausts the store of information in this handy volume. Chapter II, for instance, treats of galvanometers and describes with ample illustrations the various forms of galvanometers in use, pointing out the special adaptability of each, and generally their peculiarities and defects. Chapters XXI and XXII give formulae for determining the efficiencies of cells, lamps, motors, transformers and dynamos and of deriving magnetic determinations of fields, intensity of magnetisation, permeability, hysteresis, magnetomotive force and reluctance.

Professor Parker's book is a work that grows upon one and it does not require a close examination of it to convince one of its great value to those who have occasion to make electrical measurements of almost whatever description. To instructor and student it is indispensible; the engineer will find it of great service for its readiness in furnishing any formula that may have been forgotten and the lack of which becomes an annoyance and an embarrassment. Similarly the central station electrician who has efficiency tests to make and insulation resistances to measure or the chief operator who has the resistance of lines and cables to derive or faults to locate, or the expert who must report with accuracy upon the internal resistance of batteries or of electrolytes—all these and many others will find Parker's Electrical Measurements to be a most complete and concise text-book.

The scheme of classification which pervades the work is excellent and the impression it makes is so fa-

orable that one wonders why similar modes of graphically portraying those branches of special knowledge having ramifications, as it were, are not in more general use. The advantages of this treatment are thoroughly understood by the author, who is Instructor of Electrical Measurements of Columbia College and who emphasizes the importance of an accurate knowledge of electrical measurement and points out the lack of uniformity which appear in many instances in the methods employed. "Indeed," he observes, "it almost seems as if there were two schools of electrical measurement. But this is probably due, to some extent at least, to the lack of a proper co-ordination and classification of the subject. New methods of practice have rapidly developed, and improved instruments are constantly coming into use, so that it is not strange if there be a little confusion.

"Thus we may find a text-book that is almost perfect as far as resistance work is concerned but deficient with regard to electromotive force or current, describing at length obsolete methods and entirely omitting many of the best ones. So that often the student may be compelled to consult a great number of standard works and supplement this by long personal observation to obtain even a fair comprehension of the practical methods. The subject, it seems to the writer, should be attacked in the most systematic manner and the classification thoroughly worked out. Indeed, classification and knowledge are very nearly synonymous terms, and what follows is offered as an example of such a method of treatment."

That the reader may more clearly understand what is meant by the author's scheme of classification, reference may be made at random to any electrical function, such as electromotive force. There are considered under this division: (1) Batteries and Direct Currents, (2) Alternating Currents, (3) Very High e. m. fs., (4) Very Low e. m. fs., (5) Calibration of Voltmeters, and (6) Standards of e. m. f. Take, for instance, the subject of Alternating Currents, when from the group it appears that there are four different methods of measuring the e. m. fs. of alternating currents, viz: by the electrometer, by the dynamometer, by the caloric voltmeter and by the attraction voltmeter. There are, of course, different varieties of electrometers, such as the quadrant, the multicellular and the low-reading electrometer, as well as Thomson's and Weston's electro-static voltmeters, all of which appear in the schedule and are fully described in the text. Above all, the language of the text is clear and comprehensible and every word counts.

But one feature of importance is noted wherein the book may be considered seriously remiss, and that is in the omission of methods for determinating the values of the functions of polyphase systems. Indeed, it appears that even single phase alternating currents have hardly been treated with sufficient fulness in that means for the derivation of only voltage and amperage are pointed out, leaving the student to infer that the wattage of an alternating circuit may be found in the product of the volts and amperes. That this is always the case will not be contended by any means and that subsequent editions will bring out these points is evident from the author's confession that the book is not a finished work, but when this has been done, there will have been removed the only feature in the way of an unqualified endorsement of Professor Parker's most valuable book.

Pneumatics

COMPRESSED AIR FOR MINING PURPOSES.*

By Edward A. Rix.

It was my intention when first invited to read a paper here on compressed air, to deal with the subject of "Power Transmission by Compressed Air," inasmuch as that particular theme is just now the subject of much speculation among engineers, and of much interest to power consumers, but upon reflection it appeared to me to be a better plan, and one which would help you the most, to discuss that use of compressed air which at present most vitally affects our own interests, namely, its use in our mines.

All of you, as engineers or spectators, in traveling through the mining counties of this State, will have occasion to observe the use and abuse of compressed air in many of its more important applications, and you will feel much more at home with the subject on such occasions after listening to a paper directed to that particular end than if a general subject, such as "Transmission," was dilated upon with no particular plant in this State to offer as an object lesson.

It is not my purpose to belittle the service which is rendered by that incomparable, mysterious power which we call electricity, although I may claim that it has usurped the legitimate place of compressed air in many instances. There is no conflict between these two great agencies. Each has its proper and legitimate field of usefulness, independent of the other, and it is easy for an intelligent engineer to recognize these separate rights, and in proportion as he does, so will his work be successful. A small portion of the territory of these powers seems to overlap and it is there that we hear the noise and confusion of disputed title, and many in the midst of this turmoil lose sight of the great independent domain of each which requires development and which will yield rich return to the earnest student and worker.

Compressed air is the only power which is alone sufficient to supply all the power needs of an average mine. For lighting purposes from five to ten per cent may, if required, be converted into electricity for that purposes. Where steam or water power is used, fifty per cent, or more, is converted into compressed air, and five to ten per cent into electricity for lighting. Where electricity is used, from fifty per cent to ninety per cent is converted into compressed air, the remainder being directly used for lighting.

The reason for so great a conversion of other powers into compressed air lies in the fact that generally one-half the entire power is absorbed by pumps, underground hoists and rock drills. The two former, in nineteen cases out of twenty, are actuated by compressed air, and the latter always. It is true that both the hoists and pumps may be run by electricity economically, but as yet there has not been produced a rock drill actuated by electricity which has been a success, and inasmuch as air is required for rock drills, and as they consume more than the pumps and hoist as a rule, the mine management generally concludes to use air for all three kinds of work rather than introduce two kinds of power service underground.

I am perfectly aware that my statement regarding the failure of electric rock drills may be disputed by manufacturers of the so-called article, or by electrical

* Lecture delivered to the engineering students of the Leland Stanford Junior University, May 3, 1897.

enthusiasts, but notwithstanding all that, I shall maintain my statement true, and it will receive the support of the larger electrical concerns.

It is true that electric drills have been made by two of three firms, and on the shop floor they drill very nicely, at the rate of two inches per minute, in medium granite, for the first two feet. From that point on to four and a half feet, the average depth of a blasting hole, their drilling capacity deteriorates very rapidly. The air drill does from three to four times this work easily.

The claim for the electric drill is that it consumes but one-third the power. This is true, but if it takes three of them to do the work of one air drill, the wages of six men will have to be balanced against the wages of two men and the extra power consumption. The latter equals, perhaps, the pay of one man, so that to do the same work with the electric drill would cost twice more than for the air drill.

There are other considerations, however, independent of this, which militate against the electric drill, namely, that it will not stand the dust, mud, water, hammer beating and general rough usage, and again, it would be necessary to introduce a ventilating system for fresh air, as well as to expel smoke, where electric drills are used, while with the air machines their exhaust furnishes all necessary fresh air and ventilation.

It needs no great discernment to see, therefore, that the simplest and most desirable proposition, and the one involving the least machinery and transformation of one power into the other, is compressed air, which exchanges from five to ten per cent of itself for lighting purposes only, while any of the others must make exchange for at least 50 per cent of air and the lighting besides.

I have assumed, of course, that the cost of any of these powers delivered to the mine was equal and the motors which absorbed them were the most efficient for the purpose.

All things being equal, then, I assume from what I have seen of the various requirements of a mine for power purposes, and for the reasons given before, that compressed air is the ideal power for general mining purposes. With varying conditions, however, it is simply a matter of combining and comparing the cost of fuel or water, repairs, interest on the plant, insurance and taxes, in order to select the proper general power, and should comparisons be nearly equal, then general utility, simplicity and safety, should decide the choice.

When the preponderance of evidence is for any one of these forms of power it requires no skill to make a selection, but when all things are equal as to cost and maintenance, or nearly so, in bringing any of the powers to the mine, then I wish to show why compressed air should be the choice without hesitation, and after the choice is thus made, how to use it so as to justify the choice.

Compressed air has been abused in its use most shamefully, and until recently none of its friends have been able to be seen or heard, so intensely has the interest of the world been centered upon the marvelous results of the investigation into electrical phenomena. The mysterious has such a fascination for the ordinary mind, and the meteoric developments of electrical science have followed so thick and fast, and in so many fields of usefulness, that the average individual could be stampeded into the electrical camp by a mere mention of the name of this most elusive fluid. Now there has come a breathing spell, and the advocates of compressed air are calling attention to the fact that compressed air, properly generated and applied, owns a place in the economics of the day, and this they propose to maintain.

Compressed air has been generally understood to be a most expensive form of power, and has been given sufferance only because of its utility, since for underground work it really has no rival at any price. Because the laws of compression and expansion of permanent gases belong to the realm of higher mathematics, few understood what they were dealing with, and many of these, unable to overcome the freezing of their motors, did as the public generally did, namely, used the air at practically full stroke, and threw away all the intrinsic energy of the air which we can develop by expansion. Theoretically they thus threw away two-thirds of their power, and practically about three-fourths. Ordinary direct-acting pumps and rock drills do not even have an efficiency of twenty-five per cent. No small wonder, then, that the wood piles have dwindled rapidly away and small power results been produced. Everything was sacrificed to utility, and compressed air did not take its proper rank until engineers began to realize that it must be used expansively. To use air in an ordinary direct-acting pump is equivalent to throttling a head of water to one-fourth of its spouting velocity to accommodate the speed of a wrongly geared water wheel.

I fancy that most of the trouble on the whole subject has arisen from a misconception of what compressed air is in a power sense. Many believe that the power of the engine which compresses the air has been stored in the air compressed, and the more steam they give the engine and the harder it worries and flurries, the more work the air should finally yield up. They cannot understand that a pound of compressed air at the same temperature contains the same intrinsic energy, no matter what the pressure is, and this is originally contained in the atmosphere before it is compressed at all. This being the case, no matter what power was expended to compress one pound of air to, say, 90 pounds gauge pressure, it will have at the same temperature but one intrinsic potential stored within it. Temperature is the head—if I may use a term applied to water—from it comes the power. If by reason of a physical condition, namely, pressure, one pound of air is allowed to fall from a height represented by a temperature, 60, to one lower, represented by say,—60, that one pound will generate 184.93 foot pounds of work through every degree it falls, and so on until it reaches—461, the absolute 0, which is the bottom where in theory air has neither pressure nor volume, and its work is done. The total intrinsic energy is always 184.93, multiplied by the number of degrees the one pound of air is distant from —461 deg. Fahr.

The center of earth is the absolute 0 of water power, for there water has no weight. This corresponds to the absolute 0 of air, and every pound of water at the same distance, measured in pressure, from the center of the earth, has the same potential, and independent of its temperature, just as one pound of air has the same potential at the same distance, measured in temperature, from its absolute 0, independent of its pressure. This 184.93 is simply the 778 which represents the foot pounds of work in one British thermal unit, multiplied by 0.2377, which is the specific heat of air at constant pressure—that is to say, it is the fraction of a B. T. U. necessary to raise one pound of air one degree. The quantity of heat therefore necessary to raise the temperature of one pound of air from absolute 0 to 60 deg. Fahr., which represents a distance of 521

degrees, will be 184.93 multiplied by 521, which would be 96,348.52 foot pounds, which represents the intrinsic energy of one pound of air at 60 deg. Fahr. This, of course, presumes that no heat will be either lost or gained by radiation or otherwise during the expansion of air, and this sort of expansion is called adiabatic.

The sea level for water corresponds to the atmospheric line for air, for at these points neither will manifest motion or power. Suppose the land and water to be on a level, we could not then use any of the potential in the water, unless by some mechanical device we continually created a shaft, whose depth we would call pressure, below the sea level, for the water to fall into and generate power, and it matters not how much power it requires to maintain this shaft at any depth, one pound of water dropping into it will always yield up the same fraction of its total intrinsic potential. The same with air—at the atmospheric line we cannot avail ourselves of its potential, so we use a mechanical device, called a compressor, to prepare a shaft, as it were, which we also call pressure, whose depth we measure in degrees of temperature, and no matter how much power it takes to maintain this condition of affairs, one pound of air dropping into this shaft will always give out the same fraction of its total intrinsic energy.

I hope I have made the idea clear that I wished to convey, namely, that in neither case did the resultant power depend for its measure upon the mechanical means which caused its activity. Consequently, in compressing air the energy stored in the compressed air is not a definite function of the power required to compress it, but is a definite function of an ideal compression we call isothermal, with an empirical index determined by practice.

In order to show you, by some calculations, that the intrinsic energy in the air is independent of its pressure, and that no matter between what points of pressure you expand the air, there will always be enough power in the air left to account for its total intrinsic energy, namely, 96,348.52 foot pounds, at 60 deg. Fahr. This will show you at the same time why we depend upon the pressure to put the air in a condition to realize a portion of its intrinsic energy for work.

Taking, for instance, one pound of air at 100 pounds gauge, and at 60 deg. Fahr., if allowed to expand adiabatically to atmospheric pressure, it will produce work and consequently lose part of its heat, and we find that its temperature, after the expansion has taken place, is:

$$-173.96^\circ \text{ Fahr. or } T = T_0 \left(\frac{p}{p_0} \right)^{\frac{\gamma-1}{\gamma}}$$

The drop of temperature is $173.95 + 60 = 233.95$ degrees, and as $778 \times 0.2377 = 184.93$, the work of adiabatic expansion is:

$184.93 \times 233.95 =$ ..... 43,264.37 foot pounds

this being the useful work. The adiabatic work of expansion from —173.95 deg. Fahr. to the absolute 0 would be

$184.93 \times 287.05 =$ ..... 53,084.15 foot pounds

Total ..... 96,348.52 foot pounds,

which is the total intrinsic energy—that is to say, we have utilized 45 per cent of the total intrinsic energy.

Next, taking air at 10 pounds gauge, the temperature after adiabatic expansion to atmospheric pressure is —12.9 deg. Fahr., and the useful work of expansion is:

184.93×72.9 ..... 13,481.39 foot pounds,

The adiabatic expansion from —12.9 degrees to absolute 0 would give

$184.93 \times 448.1 =$ ..... 82,867.13 foot pounds

Total ..... 96,348.52 foot pounds,

i. e., the total intrinsic energy, and the useful work is here 14 per cent of the total intrinsic energy.

It is hardly necessary to say that these figures are theoretical, because, in practice, part of the work of expansion, and consequently part of the heat, is absorbed by the friction of the piston in the cylinder, and lost by radiation from the various pieces of the machines.

We see ,therefore, that the only portion of the intrinsic energy of air that is practically obtainable is the expansion work which it does above atmospheric pressure, i. e., that the pressure of this air must be raised above the pressure of the atmosphere.

I have spoken only of the energy stored in the air after it is compressed. There is, however, a perfectly mechanical translation of energy from the prime mover to the air motor, that we call the energy of full pressure and is that part of the work performed in an air compressor or given out in a motor which takes place at constant temperature, or, in other words, is the work performed by the piston to discharge the air from the cylinder. I might call it an air piston rod, which reaches from the compressor to the motor, and conveys the energy of one to the other absolutely mechanically and in the case of isothermal compression would act just the same as if a column of water reached from the compressor piston to the motor piston. It is nothing but a flexible piston rod, acting during the period of full pressure only, and stops when the compressor stops, unless the air receiver be infinite in its capacity. It is this air piston rod only, which direct-acting pumps and ordinary motors and rock drills use, thus availing themselves of a mere mechanical phase incident to the operation of a compressor and abandoning entirely the real work which is stored in the compressed air itself, and which is practically three times the value of the other. It would be just as sensible to judge the economy of a steam engine by its full pressure work only, as to do so in an air engine.

I have been thus explicit on this somewhat puzzling point because I wish it well understood that the least possible power expended in compression gives the highest resultant efficiency and is the first condition precedent to an economical air plant. You are all no doubt familiar with the way to produce this, namely, highest form of prime motor, compound compression where proper minimum frictions in all moving parts, slow piston speeds, least clearances, large valve areas and cooling surfaces, so that heat of compression shall be as nearly constant and at initial temperature as possible, or, in other words, isothermal. It is always, you perceive, a case of temperatures.

Now, in using the air after compression, or, in other words, to utilize as much of its intrinsic energy as possible, we become involved in a case of temperatures again, and it is precisely the reverse in all ways and considerations of the phenomena of compression. If it be true that difference of temperature between the admission and exhaust of the air in a compressor is the head to be overcome by the prime mover in reaching a certain receiver pressure, it is evident this difference should be made as small as posible, and reversing the case for air motors it is evident it should be made as large as possible. Everything would tend toward the accomplishment of this fact readily, were it not for the

presence of moisture in the air, which while it offers no difficulty to compression, which is a heat-developing phenomenon, freezes at once during expansion, which is a cold-producing phenomenon. This freezing has nothing to do theoretically with the perfect operation of the air in its expansion, but practically it fills up the valve ports with ice, congeals the lubricants, and the motor stops. These temperatures range often as low as —150 degrees.

Inasmuch as it matters not between what degrees of temperature we do our expansion, so long as we maintain the same difference, it must occur to the engineer at once that if, in expanding from atmospheric temperature downward, he meets with the mechanical obstruction of ice, he must slide his range of temperatures up the scale until the final exhaust temperature shall be such that ice will not form. Inasmuch as this cannot be done without supplying extraneous heat, either before or during expansion, the idea of reheating is at once suggested, and upon it hinges the whole subject of the economical use of compressed air.

In determining the amount of heat to be applied to the air before use, it will be found that no great temperatures are required, averaging generally about 150 deg. Fahr. to exhaust at 32 deg. Fahr., and give complete expansion to atmosphere.

Inasmuch as every degree we add to the temperature of the air before use increases its head, provided we exhaust always at the same temperature, and inasmuch as lubricants will not be destroyed at 400 deg. Fahr., or even more, it comes as a natural conclusion that while we are reheating we should go to the practical limit, and especially as it is found by experience that the additional fuel required is of little consequence.

The increase of power obtained by this increase of volume (for that is the way the increased temperature manifests itself) ranges from 0 to 60 per cent, at an expenditure for fuel which, after reducton to terms of the prime mover power, means an addition of from zero to ten per cent of that power, depending upon the head and price of water, or price of fuel. A gain of fifty per cent at an expenditure of ten per cent may in some cases be made to cover all losses of compression and transmission, and deliver to the motor the full amount of power expended upon the air at the compressor, or even more.

It need not be demonstrated here that the use of fuel to expand air is from five to seven times more economical than it can be used in any other manner to generate power.

Having thus shown you the proper and natural conditions under which to compress and to use air after it is compressed, and having also called your attention to the requirements of a modern air compressor, the motor is the last thing and the most important thing to be considered. It appears to me that inventors and builders of compressed air machinery are devoting too much time to the compressor and none at all to the special air motor. Compressors can be made having an efficiency approximating ninety per cent, while the average motor using the air from such a compressor would not give forty per cent.

To those who care to put thought on the subject of compressed air I would suggest the subject of special motors and reheaters, as a field offering both honor and remuneration. The advocates of compressed air would gain several points if they would pattern after the methods of electrical engineers, who have claimed from the very beginning that nothing was too good in the shape of material or machinery for the development of electrical power. The very finest and most efficient prime motors are always insisted upon, even down to insignificant plants, and the splendid construction of generators and installation of machinery and appurtenances, scarcely without regard to cost, has enabled them to place their product upon a high engineering plane. Their methods and their ideas for the advancement of their interests have been correct, and they are justly entitled to a commensurate reward.

How all this contrasts with the miserable class of compressed air machinery which until the last twelve months has been installed throughout the country. The very cheapest of slide valve engines, or some jumping, flapping belt for prime movers; poorly designed, poorly made compressors, with insufficient valve areas and cooling devices; generous clearances; enormous piston speeds; all and everything done to make a machine as cheap and undesirable as possible. For motors, anything that would reciprocate, the valve motions causing the pistons to meter out nicely the air in solid chunks at full pressure; the real work being done at the end of the exhaust pipe, and I might add that the louder the noise of escape the more work was supposed to be done in the cylinder, whereas in reality the air was simply making a louder protest at its misuse.

All this must change, and is changing, and an awakening is at hand. It is the duty of every pneumatic engineer to insist upon high-class installations, not only for his personal success, but for the advancement of compressed air, that most willing, useful and satisfactory power medium ever given to the service of mankind.

(To be continued.)

Correspondence.

The Journal of Electricity is not Responsible for Opinions Expressed by Correspondents.

INSULATORS FOR HIGHER POTENTIALS.

To the Editor:

Sir:—I have read with interest the leading article in the May number of the Journal upon the Riverside transmission and also note in the same issue the editorial regarding insulators for extremely high potential use, in which you state that the only thing lacking to transmit very high potential is a perfect insulator.

I would like to say that in my opinion it is not very difficult to make an insulator of sufficient strength, mechanically and electrically, to meet the requirements, but a commercial difficulty stands in the way in the matter of cost. With the principle involved in my new two-part insulators, I can make them to carry any potential that it is practicable to use, but the cost involved in the manufacture of such insulators is considerable and on long transmission lines it will make the insulation cost so much that it is sometimes impracticable to use them because the power may be worth no more after being transmitted 100 miles than though it were transmitted 10 miles.

I have the insulator to meet the requirements and am working hard every minute to reduce the cost of manufacture to allow its adoption for all classes of work.

FRED M. LOCKE.

Victor, N. Y.

Fraternal.

THE ELECTRIC TRANSMISSION ASSOCIATION.

A meeting was held at the offices of the Blue Lakes Water Company in the Crocker building, San Francisco, on June 11th to effect the organization of the Pacific Coast Electric Transmission Association. The companies represented at the meeting were the Blue Lakes Water Company of San Francisco, the Big Creek Power Company of Santa Cruz, the Southern California Power Company of Redlands, the Central California Electric Company and the Sacramento Electric, Gas and Railway Company of Sacramento, the San Joaquin Electric Company of Fresno, the Power Development Company of Bakersfield, the Portland General Electric Company of Portland, Or., the Nevada County Electric Power Company of Nevada City and the San Gabriel Electric Company of Los Angeles.

An organization was definitely settled, with the objects of mutual protection and the collection and dissemination of information relative to the generation, transmission and distribution of electrical energy. The officers elected were: President, C. P. Gilbert, manager of the Sacramento Electric, Gas and Railway Company; Vice-President, H. H. Sinclair, manager of the Southern California Power Company; Secretary and Treasurer, Robert McF. Doble, Secretary of the Blue Lakes Water Company; Executive Committee, W. Frank Pierce, President of the Blue Lakes Water Company, and J. J. Seymour, President of the San Joaquin Electric Company.

The annual meetings of the association will be held in San Francisco, while other meetings will be held at intervals at the various power stations throughout the Coast, when papers will be prepared and read on topics of interest in matters electrical, the different methods adopted at the different plants for obtaining particular results, etc.

At the first meeting there was an informal discussion in regard to insulators. The same subject will be taken up and discussed formally at the next meeting, which is to be held at Santa Cruz about the middle of August.

The association will not accept as members any dealers in electrical or other supplies, or the representative of any manufacturer.

THE GOOD TIMES ARE HERE.

That the California Electrical Works is fast forging to the front in the race for supremacy of the electrical business of the coast is evident from the number of big contracts it secured during the month of April. Among these are the installation of iron armored conduit systems in the Claus Spreckels and Spring Valley Water Co.'s Buildings, and the closing of yearly contracts for the supply of Buckeye incandescent lamps to be used exclusively by the Pacific Mail Steamship Co., the Southern Pacific Co., the Market Street Railway Co., and the Pacific Improvement Company. The considerations for those contracts alone reach tens of thousands of dollars. Among the smaller business transacted may be named the sale of Warren alternators, a 60 k. w. machine, going to Anaheim, Cal., and a 30 k. w. machine to Porterville.

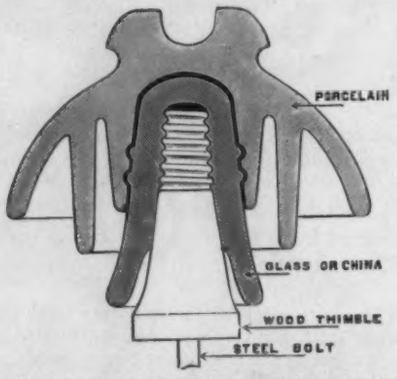
Industrial.

In Responding to Advertisements in this Publication, please mention "The Journal of Electricity."

HIGH POTENTIAL INSULATORS.

In no department of engineering has it been so fully or so frequently demonstrated that good work and good material pay as in the field of electrical applications of power. Cheap devices, like cheap labor, mean a constantly increasing repair account, the reduction of which unnecessarily large item of expense means dividends to the operating company. Moreover no feature in electrical transmission is more essential to absolute permanance and reliability of operation than the line and to perfect the materials used in line construction has been the untiring effort of Mr. Fred M. Locke, of Victor, N. Y., for years past.

The latest of Mr. Locke's production is the extremely high potential insulator shown in outline in the accompanying cut. It is a two-part insulator designed to carry potentials up to 50,000 volts, and is made in different sizes according to the current carried. It has an outer shell of Chinaware on account of its high insulating surface and its mechanical and electrical strength, and has a center insulator of glass as shown in the accompanying sectional view, to further insulate it and to prevent puncture by the high potential current. It is also made of two or more shells of china ware, the advantage of this over one solid insulator being that the shells being made separately ½ inch thick, each allows more uniformity in making and more through vitrifaction, than could be obtained otherwise in one solid insulator 1 inch thick. Besides this are secured four thicknesses of glazing from the



SECTIONAL VIEW OF THE LOCKE EXTREMELY HIGH POTENTIAL INSULATOR.

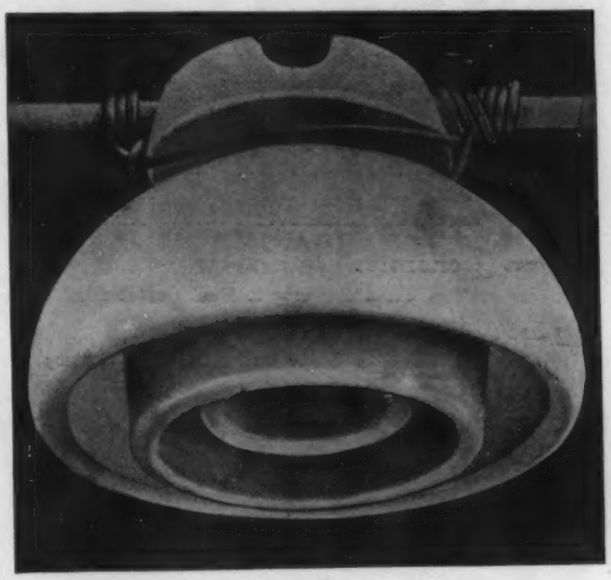
two shells, which further increases its insulating qualities.

By repeated practical tests it has been found that a potential of 100,000 volts will not puncture the insulator; hence it will carry with safety and economy any voltage that is practicable for use in commercial application of electric power.

The body and glaze of all the Locke insulators are of simple earths only, fused together into a vitreous, homogeneous mass at the greatest heat. No lead or other metallic oxide being used in making, and the glaze is not a conductor. The body and glaze being of exactly the same material and fired at the same heat the insulating qualities are as high without as with the glaze.

These Insulators will not craze or crackle on the surface or "leak" as insulators made of inferior material will do when subjected to variations of temperature. The ware used in their construction will stand severe tensile strains or heavy blows without injury, and will not crack or chip from the effects of high potential currents.

Heat, cold, dampness, acids, alkalies cannot act to disintegrate or otherwise injuriously affect the properties of them, as their structure resists the action of gaseous and fluid substances as well as of other forces.



THE LOCKE TRANSMISSION INSULATOR.

No other insulator possesses, or maintains to such a high degree, all the essential qualities of high insulation resistance here being the best, it is the cheapest.

The Locke pin is made especially for the heavy work and good insulation required in the highest potential transmissions. The belt has a diameter of ½ inch and has a wood top of five inches above the arm with a 2½ inch base. It is boiled in paraffine, making it water-proof and a good insulator. The art of preparing the wood so it will absorb the paraffine is not generally known. In some instances when wood pins were supposed to be boiled in paraffine, a test showed them to be of little benefit; but if the pin is properly treated, it can be made to show a high resistance for years. The wood on these pins is properly treated. All Locke pins are made for standard cross-arms, but can be had for any size arm.

Mr. John Martin, is handling the Locke line materials as Pacific Coast agent, in conjunction with the agency of the Stanley Electric and Manufacturing Company, with offices and warerooms at 300 California street, corner of Battery street, San Francisco.

WALKER ALTERNATOR.

In designing the Walker Alternator, of which a cut is presented in the advertising pages, the Walker Company has endeavored to conform to the general outlines which have become familiar to the public during the last few years, as distinguishing the Walker Generators. The single casting, including base and end bearings, the ample self-oiling bearings, the copious oil wells, the interior motor and the horizontally divided external ring, correspond in general appearance to the other types of Walker apparatus.

The machine is of the type known as an "Inductor Alternator." In adopting this type, the Walker Company has followed its usual practice of not exploiting new and untried types of machinery, but of adopting a type which has been in existence sufficiently long for its principles to be thoroughly familiar to the manufacturer, and its marked advantages as well known to the public. Some advantages distinguishing this type in general, and this machine in particular, may be seen from a study of the different parts of the generator.

A solid iron casting is keyed to the rotating shaft. The hub, together with the outwardly projecting arms or spokes with laminated iron tips, forms part of the magnet circuit.There are no windings upon this rotor, no insulation to chafe or jar loose, no sliding contacts offering continual opportunity for trouble. The function of the rotor is (1st) to provide a path for the magnetic field, and (2d) as part of the magnetic circuit, to vary the position of the magnetic flux, relative to the armature coils.

To the interior of the fixed ring, shown in the cut, are secured annular laminations. These armature laminations are furnished with inwardly projecting teeth and support the armature coils. There are twice as many armature coils as there are inductor projections, and at any instant half the coils lie opposite these, and half opposite the spaces between the inductors. The armature lying external as it does to the inductor gives room for ample cross section of conducting wire, without infringing on the space necessary for insulation. The coils, themselves, are thoroughly insulated in the process of construction; and again, the sides and bottom of the slots are lined with composite insulation of the best materials before receiving the coils. Thus the insulation between armature windings and frame is of the highest quality, and being upon the stationary portion of the machine, is not exposed to the slow disintegration which deteriorates some varieties of insulation upon revolving armatures.

The inductor and armature together form a discoidal box, the stationary armature ring being the periphery. One side is closed by the projecting arms of the inductor; the other by a casting continuous with the armature ring, and extending radially inwards, leaving only the necessary clearance between it and the inductor hub. Within this annular box, concentric with the shaft and securely bolted to the armature casting, is the coil supplying the excitation necessary for the machine. The magnetic lines generated by this coil, starting from the armature ring, flow inwards along the side of the armature casting, across the air-gap into the inductor hub, out along the inductor arms and through the laminated tips, across the air-gap into the amature teeth; the changing position of the inductor arms supplies the variation of magnetic flux through the armature coils necessary to produce the required voltage.

A further advantage of this machine is the accessibility of different parts for repair. The planed surfaces of the base allow the armature to be slid parallel to the shaft far enough for inspection and minor repairs to the armature coils and field. If it should be necessary to dismantle the machine, the operation is simple. The field coil is unbolted from the armature casting

and supported by the inductor. The top half of the armature is removed and the operation is completed by lifting out inductor and field coil together.

A WATER-MOTOR FAN.

The Brooks-Follis Electric Co., always on the lookout for something new and attractive, are now placing a fan motor on the market to be operated by water. In many places the electrical current is not available in the day time for fan motor use, but water is most always easily obtained.

The Cox Water-Motor and Fan is designed and constructed on mechanical and scientific principles by one of the best mechanics in this country. It is simple, durable and neat of construction, consisting of three parts only, the wheel, case and back, all of the best quality, and by quality is meant the best of material, skilled workmanship and rigid inspection. The case and back are of cast iron. The bearings each are 1 1-8 inches long and made of brass. The vanes of the wheel are also of brass, and therefore will not rust out.

It is very economical in operation and consumption of water, consuming one-third less than any other motor on the market, and can be operated on a pressure of thirty-five to one hundred pounds. By using two jets of 1-16 of an inch and less, according to water pressure, each jet alternating with the other in striking the outer edge of the vane thereby, there is obtained a very rapid, steady and noiseless motion, producing a very powerful breeze.

The entire outfit is a "thing of beauty and a joy forever," and an ornament wherever placed. It is as easily installed as an electric fan, connecting with any convenient water pipe or hydrant, and is guaranteed not to leak. It is just the thing for counters, offices and stores, or any place where a fan is desired.

As electrical current is not always procurable, the Brooks-Follis Electric Co., is raising the "wind" in more ways than one, as anyone can easily see by stepping into their office and seeing their display of Water and Electric Fan Motors. They are carrying the Westinghouse, Lundell, Emerson and the Hunter-Deteurk Fan Motors, in addition to the Cox Water Motor. It will pay anyone contemplating putting in a Fan Motor to investigate their line.

The Brooks-Follis company is also placing an arc lamp on the market that is meeting with a ready sale. The lamp is of the long burning type, burning 150 hours without retrimming. It gives 450 candle power and consumes only 200 watts per hour, and is but 20 inches over all, being finished in polished brass. Either for direct or alternating current. Send for further information.

TABLE OF CONTENTS

Abbreviations: Illustrated (*); Editorial, (Ed.); Educational, (Educ.); Electro-Economics, (Elec-Econ.); Electro-Insurance, (Elec-Ins.); Electro-Therapeuty, (Elec-Ther.); Financial, (Fin.); Hydraulics, (Hyd.); Illumination, (Ill.); Literature, (Lit.); Metallurgy, (Met.); Mining, (Mi.); Passing Comment, (P. C.); Physics, (Phys.); Pneumatics, (Pneu.); Telegraphy, (Teleg.); Telephony, (Telep.); The Trade, (T.); Transmission, (Transm.); Transportation, (Transp.)

Authors

Replogle, Mark A.....49
Rix, Edward A.,.....54
Sprout, Sidney.. .....).....47

Editorial

A Favor Solicited,.....50
A Novel Endorsement.....50
Engineering Difficulties in China.....51
The Berliner Consolation.....50

Electro-Economics

Shall Plant Costs Conform to Fuel Costs? (P. C.)....52

Hydraulics

The Government of Water Power, By Mark A. Replogle49

Industrial

*A Water Motor Fan.....59
*High Potential Insulators.....58
The Good Times are Here.....60
The Walker Alternator.....58

Literature

A Systematic Treatment of Electrical Measurements, by Herschel C. Parker.....53

Miscellany

Insulators for Higher Potentials, by Fred. M. Locke,..57
The Electrical Transmission Association.....60
The Penalty for Breaking a Contract.....53

Mining

*Are Mineral Lodes of Electrical Formation? By Sidney Sprout.....47
Compressed Air for Mining Purposes, by Edward A. Rix.....54

Passing Comment

Shall Plant Costs Conform to Fuel Costs?.....52
A Manufacturer's Rights Upheld.....52
Liquid Air and Power Transmission.....52

Personal

Chesny, C. C.....48
Harrison, W. Stuart.....48
Lee, F. V. T.....48
Perrine, Dr. F. A. C.....48
Porsh, Leon.....48

Pneumatics

Compressed Air for Mining Puposes, by Edward A. Rix.54
Liquid Air and Power Transmission (P. C.).....52

Steam

*The Pacific Power Plant.....37
Central Condensers.....48
Shall Plant Costs Conform to Fuel Costs, (P. C.).....52

Transmission

*The Pacific Power Company.....37
Liquid Air and Power Transmission, (P. C.).....52
Insulators for Higher Potentials, by Fred. M. Locke, (Cor.).....57